METHODS AND COSTS OF MINING LIGNITE IN NORTH DAKOTA

BY J. N. VAN SANT AND R. C. ELLMAN

Information Circular 7891

UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary
BUREAU OF MINES
Marling J. Ankeny, Director

1959

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TN295
U53
no.7891

The Library of Congress has cataloged this publication as follows:

Van Sant, Joel N

Methods and costs of mining lignite in North Dakota, by J. N. Van Sant and R. C. Ellman. [Washington] U. S. Dept. of the Interior, Bureau of Mines, 1959.

iv, 82 p. illus., maps, tables. 27 cm. (U. S. Bureau of Mines. Information circular 7891)

1. Lignite—North Dakota. 2. Strip mining. I. Ellman, R. C., joint author. II. Title. (Series)

[TN295.U4 no. 7891] Int.59–40

U. S. Dept. of the Interior. Library
for Library of Congress

Generated on 2024-09-21 17:42 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

Original from
THE OHIO STATE UNIVERSITY

CONTENTS

	Page
Summary	1
Acknowledgments	2
Introduction	2
Lignite area	5
Topography and climate	5
Description of coal beds	5
History and production	7
Labor and living conditions	8
Consuming area and freight rate for rail shipment of lignite	9
Development practice	9
Prospecting	9
Sampling and analysis	12
General mining practice	13
Stripping	14
Climatic conditions affecting operations	15
Drilling and blasting practice	16
Loading	18
Percentage of extraction	18
Drainage	20
Haulage	22
Preparation	25
Crushing and screening	25
Dedusting and freezeproofing	31
Storage	31
Overall production rates	32
Auxiliary operations	32
Type of equipment	32
Power sources and rates	33
Fire prevention	38
Safety and first-aid organization and training	38
Supervision and management	38
Wage and contract systems	38
Cost of mining lignite in North Dakota	40
Individual mine operations	40
Baukol-Noonan, Inc.	40
Noonan mine	40
Knife River Coal Mining Co.	49
Beulah mine	49
Truax-Traer Coal Co.	55
Custer mine	55
Dakota Star mine	56

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

CONTENTS (Con.)

Page

Kincaid mine 63
Velva mine 72
Appendix 81

ILLUSTRATIONS

Fig.

1. Location map 3
2. Generalized geologic column of lignite-bearing rocks showing relative stratigraphic position and thickness of the coal beds 4
3. Modern camp, Dakota Star mine, Truax-Traer Coal Co... 8
4. Prospect-drilling sequence and pattern 11
5. Lignite bed stripped and cleaned for loading 16
6. Wagon drill used to drill lignite for blasting (drill cuttings indicate drill-hole pattern), Dakota Star mine, Truax-Traer Coal Co. 17
7. Loading lignite with power shovel into rear-dump truck, Beulah mine, Knife River Coal Mining Co. ... 19
8. Pump station in pit behind loading shovel; trailing power cable supported above haulage road by bridge constructed of pipe. (Arrow points to pump station.) 21
9. Sump and pump station used to predrain lignite bed in east section of Velva mine, Truax-Traer Coal Co. (Arrow points to sump and pump station.) 23
10. Maintained haulage roads permit fast travel. Truck returning to Kincaid mine pit after dumping load at tipple 24
11. Sketch showing how ramps are cut in overburden on highwall side of pit to provide access to each consecutively mined strip of lignite 26
12. Sketch showing how ramps are constructed through spoil piles to provide access to each consecutively mined strip of lignite 26
13. Velva mine tipple, Truax-Traer Coal Co. 28
14. Storage tanks, for spray oil, heater, and pumphouse, Velva tipple, Truax-Traer Coal Co. 29
15. Curves showing relationship between number of days mines are operated per month and tons of lignite produced per man-day for the month 33
16. Portable transformer station and safety junction box used to connect trailing cable to 4,160-volt powerline 35
17. Map of Baukol-Noonan, Inc., open-pit lignite mine near Noonan, Divide County, N. Dak. 44
18. Baukol-Noonan, Inc., method of strip mining two lignite coal beds by walking dragline 45

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

ILLUSTRATIONS (Con.)

Fig.		Page
19.	Baukol-Noonan, Inc., method of mining lignite coal ..	47
20.	Flow plan of Baukol-Noonan, Inc., lignite preparation plant, Noonan, Divide County, N. Dak.	50
21.	Knife River Coal Mining Co. lignite preparation plant flow plan, Beulah, Mercer County, N. Dak.	54
22.	Plan for removing overburden with dragline and shovel, stripping in tandem at Truax-Traer Coal Co. Dakota Star mine near Hazen, N. Dak.	59
23.	Stripping shovel, 10-cubic-yard dipper, Dakota Star mine, Truax-Traer Coal Co.	60
24.	Flow plan of Dakota Star mine preparation plant, Truax-Traer Coal Co., near Hazen, Mercer County, N. Dak.	62
25.	Map of Kincaid open-pit lignite mine, Truax-Traer Coal Co. near Columbus, Burke County, N. Dak.	66
26.	Plan for removing overburden from two lignite coal beds with a Marion-Model 7400 walking dragline at Kincaid mine, Truax-Traer Coal Co., Columbus, N. Dak.	67
27.	First phase of stripping with dragline, and mining split upper lignite bed with two shovels working in series, Kincaid mine, Truax-Traer Coal Co.	69
28.	Flow plan of Kincaid mine preparation plant, Truax-Traer Coal Co., near Columbus, Burke County, N. Dak.	71
29.	Stripping overburden by using a shovel and tower excavator in tandem at Velva mine, Truax-Traer Coal Co., Velva, Ward County, N. Dak.	74
30.	Revolving shovel and high-tower excavator operating in series to remove overburden at Velva mine, Truax-Traer Coal Co.	75
31.	Alternate method used to remove overburden at Truax-Traer Coal Co., Velva mine, using a tower excavator and a stripping shovel.	77
32.	Flow plan of Velva mine preparation plant, Truax-Traer Coal Co., Ward County, N. Dak.	79

TABLES

1.	Minimum rates for railroad shipment of industrial lignite from mines to selected cities.	9
2.	Summary, costs of producing lignite in North Dakota, 1955-56.	41
3.	Distribution of direct mining costs, percent.	42
4.	Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Baukol-Noonan mine.	49

Generated on 2024-09-21 17:44 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLES (Con.)

		Page
5.	Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Beulah mine	55
6.	Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Dakota Star mine	63
7.	Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Kincaid mine	72
8.	Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Velva mine	80
9.	Proximate analyses of North Dakota lignite on as-received basis	81
10.	Ultimate analyses of North Dakota lignite on as-received basis	81
11.	Heat value of North Dakota lignite, British thermal units	82
12.	Fusibility of North Dakota lignite ash, °F.	82

Generated on 2024-09-21 17:44 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

Original from
THE OHIO STATE UNIVERSITY

METHODS AND COSTS OF MINING LIGNITE IN NORTH DAKOTA[1/]

by

J. N. Van Sant[2/] and R. C. Ellman[3/]

SUMMARY

Lignite mining in North Dakota was begun about 1884 to supply the domestic needs of settlers. Annual production has grown rather slowly but steadily, exceeding 3 million tons in 1950. The western part of the State has lignite reserves, amounting to 351 billion tons, underlying an area of 28,000 square miles.

Contour strip mining has almost completely replaced underground mining as the method of production. Lignite is often found under rather shallow and easily removed overburden, and this is the primary reason for the change in mining practice. Current mining operations are conducted where the overburden is 30 to 70 feet thick. Contour strip mining results in high production rates, at present 27 to 56 tons per man-day. These high production rates result in relatively low production costs.

The 6 mines discussed in this report supplied approximately 70 percent of the lignite produced in North Dakota in 1955. For 4 mines, the cost of stripping, loading, haulage, and preparation averages 73.70 cents per ton of lignite produced and is distributed approximately as follows: Labor, 56 percent; supervision, 6 percent; and supplies (including power), 38 percent. Overhead costs average 40.54 cents per ton. The weighted average total cost is $1.32 per ton, exclusive of the contribution to the United Mine Workers' Welfare Fund.

About 75 percent of the output is used by powerplants to produce electricity. Since the State's economy is agrarian, use of lignite in North Dakota is limited. The present freight-rate structure and inherent low heating value of lignite limit the area that can be supplied in competition with fuels from other sources. Expansion of lignite production will depend upon future changes in the State's economy from agrarian to industrial.

1/ Work on manuscript completed March 1958.

2/ Mining engineer, Bureau of Mines, Region III, Denver, Colo.

3/ Supervisor, Preparation Section, Lignite Experiment Station, Bureau of Mines, Region III, Grand Forks, N. Dak.

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

Original from THE OHIO STATE UNIVERSITY

ACKNOWLEDGMENTS

Grateful acknowledgment is made to the many persons who helped in preparing this report. Contributions included maps, flowsheets, management details, operation and cost data, and maintenance information. Personnel of the Truax-Traer Co., including Howard Truax, Lewis Larson, James Rist, and Alfred Kelsven, provided data for their company. R. W. Rovelstad, Edgar Sanberg, and Alvin Dihle, and other personnel of Baukol-Noonan, Inc., furnished material on operations of Noonan mine. A. S. Kane, R. W. Easton, and members of their staff contributed information about the activities of Knife River Coal Mining Co.

INTRODUCTION

This paper is one of a series being prepared by the Federal Bureau of Mines on mining methods and costs in various mining districts of the United States.

The report describes mining and preparation methods in the North Dakota lignite-producing area. The material, including costs, was obtained from a study of operations at the Kincaid, Velva, Custer, and Dakota Star mines of Truax-Traer Coal Co.; the Noonan mine of Baukol-Noonan, Inc.; and the Beulah mine of Knife River Coal Mining Co. These 6 mines produced over 70 percent of the approximately 3,000,000 tons of lignite mined in North Dakota in 1955. The mines are open pits in Divide, Burke, Ward, McLean, and Mercer Counties and have been opened, in general, along the northern and eastern parts of the coal beds. (See fig. 1.)

The lignitic coal beds of western North Dakota occur in the Fort Union formation of the Paleocene age. (See fig. 2.) Estimates of reserves range from 351 to 600 billion tons. The larger estimate was based on broad, general assumptions as to the thickness, continuity, and number of lignite beds in 32,500 square miles of the Fort Union formation. The more conservative 351-billion-ton estimate was obtained from data on thickness and continuity of coal beds actually mapped in a 28,000-square-mile area of the Fort Union formation.4/

Certain phases in operations of the mines described are generally similar. They are: Exploration and prospecting, sampling, development and mining, extraction, mine drainage, wage contracts, fire prevention, safety, supervision and management, and coal preparation. The methods commonly used are described under appropriate headings.

A description of each mine, including its history, location, output, number of men employed, type of overburden, character of coal bed, water conditions, equipment used, preparation-plant flowsheet, and data peculiar to the mine, is included in the section describing the particular mine operation.

4/ Brant, R. A., Lignite Resources of North Dakota: Geol. Survey Circ. 226, 1953, 78 pp.

Generated on 2024-09-21 17:44 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

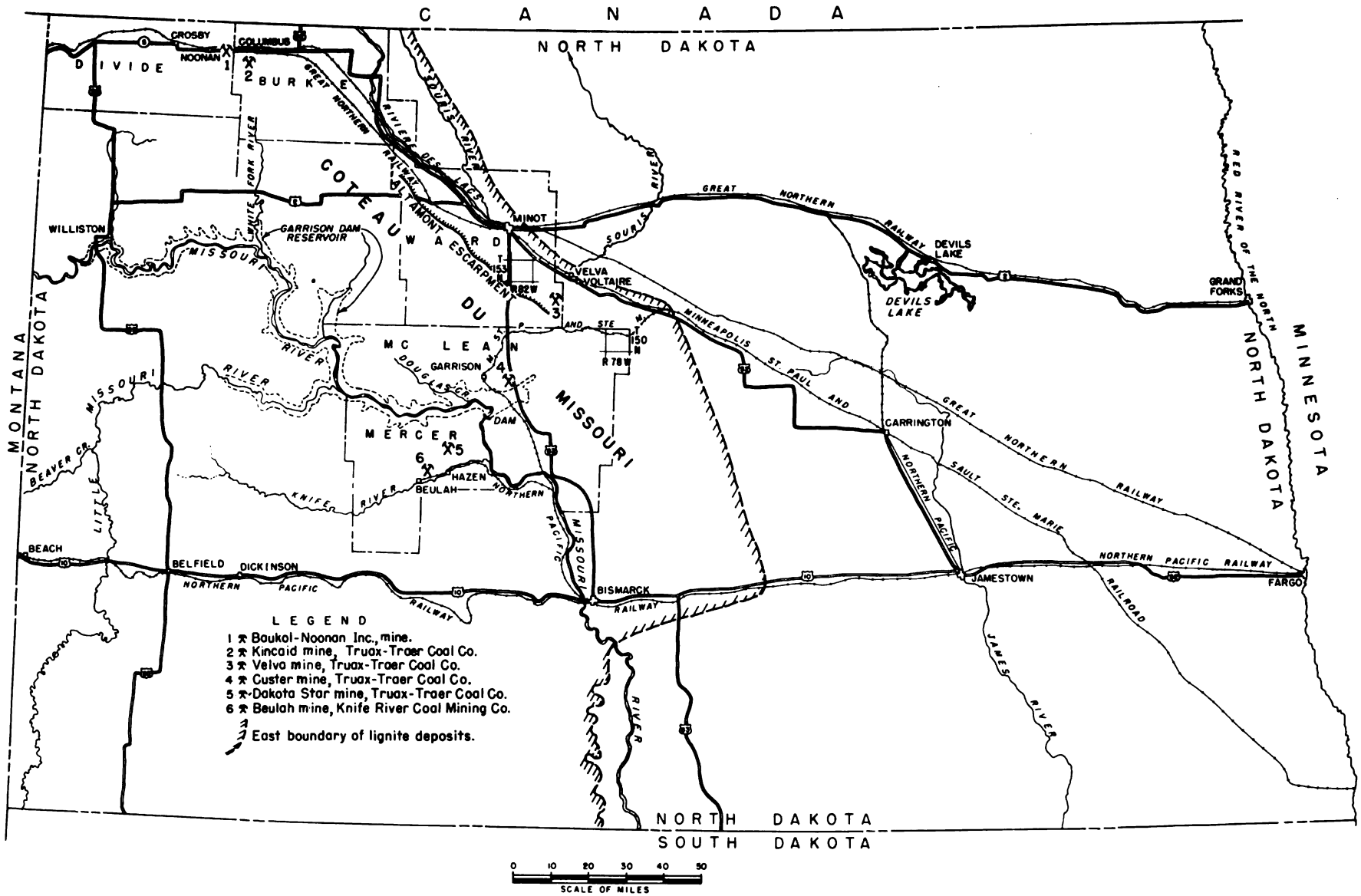

FIGURE 1. - Location Map.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

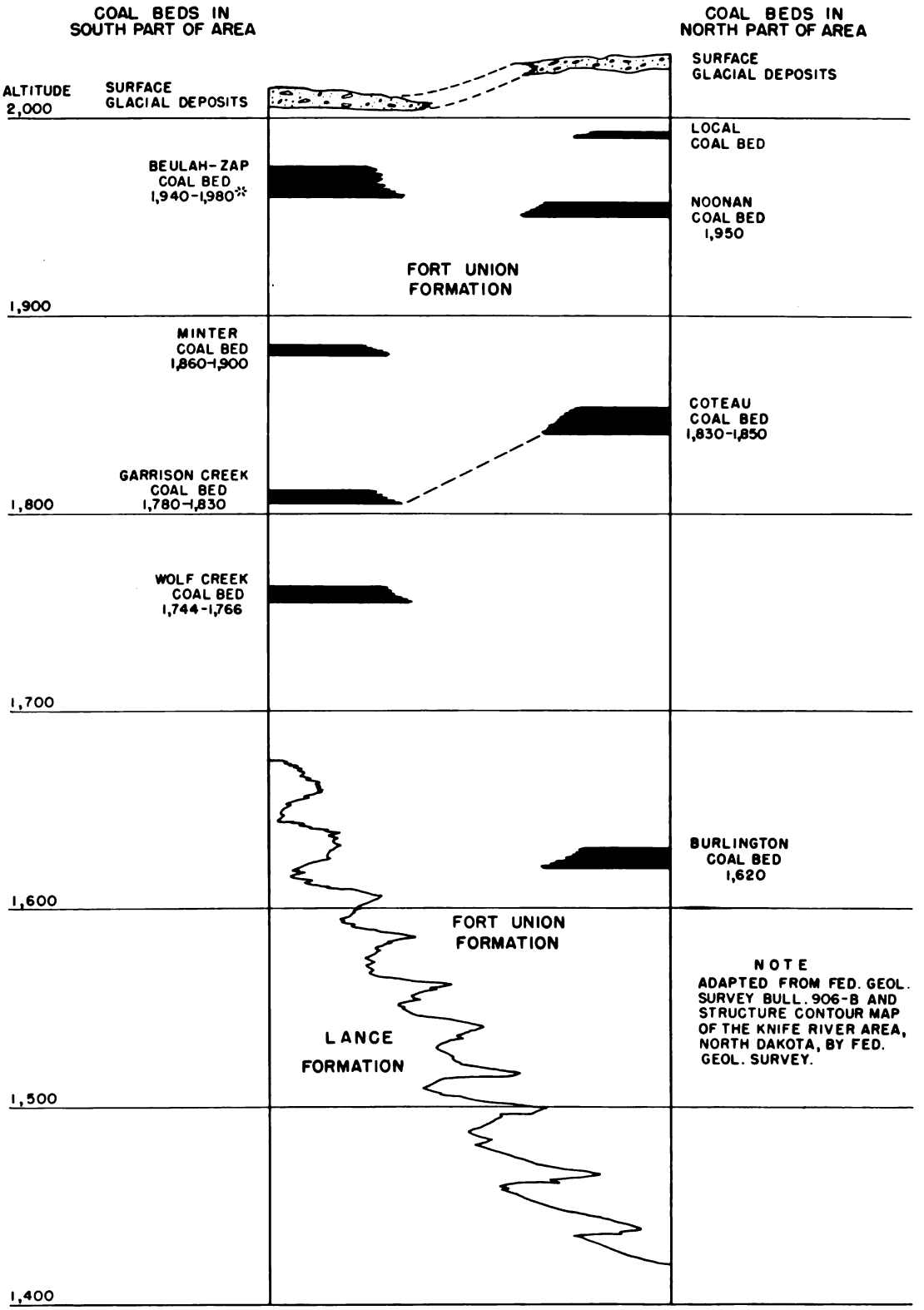
COAL BEDS IN SOUTH PART OF AREA
COAL BEDS IN NORTH PART OF AREA
ALTITUDE
2,000
SURFACE GLACIAL DEPOSITS
SURFACE GLACIAL DEPOSITS
LOCAL COAL BED
BEULAH-ZAP COAL BED 1,940-1,980*
NOONAN COAL BED 1,950
FORT UNION FORMATION
1,900
MINTER COAL BED 1,860-1,900
COTEAU COAL BED 1,830-1,850
GARRISON CREEK COAL BED 1,780-1,830
1,800
WOLF CREEK COAL BED 1,744-1,766
1,700
BURLINGTON COAL BED 1,620
1,600
FORT UNION FORMATION
LANCE FORMATION
NOTE
ADAPTED FROM FED. GEOL. SURVEY BULL. 906-B AND STRUCTURE CONTOUR MAP OF THE KNIFE RIVER AREA, NORTH DAKOTA, BY FED. GEOL. SURVEY.
1,500
1,400
* APPROXIMATE ALTITUDE, OR RANGE OF ALTITUDES, OF BASE OF COAL BEDS

FIGURE 2. - Generalized Geologic Column of Lignite-Bearing Rocks Showing Relative Stratigraphic Position and Thickness of the Coal Beds.

Generated on 2024-09-21 17:44 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

LIGNITE AREA[5/]

Topography and Climate

Most of the region containing the lignite deposits lies along the northeast border of the Missouri Plateau, a major part of western North Dakota. The Missouri River, which is 200 to 300 feet below the plateau, flows generally southeastward through the area. The Riviere des Lacs and Souris River roughly limit the lignite-bearing area to the northeast. These rivers about parallel the Missouri River within the region, and the divide between them is known as the Coteau du Missouri.

South and west of Minot altitudes range from 1,675 to 1,720 feet along the Missouri River and north of Minot, from 1,520 to 1,640 feet along the Souris River and Riviere des Lacs. Plains rise gently from the rivers toward the hummocky divide called the Altamont escarpment, which extends generally southeastward. A few of the hills forming the divide have altitudes above 2,300 feet.

The Altamont escarpment, rising 100 to 200 feet above the plain, can readily be observed as a fairly steep bluff several miles southwest of and parallel to the Souris River and Riviere des Lacs. Between Minot and Velva, the ground south of the Souris River rises steeply and is known as the Souris escarpment.

Dissected plains, gently rolling hills, and escarpments are the topographic features generally found throughout the rest of the area.

Western North Dakota has a semiarid climate. According to records of 4 United States Weather Bureau stations, the average annual precipitation ranges from 15.65 to 17.71 inches but may vary greatly from the average in any year. Most of the rain falls during the summer. The average temperature has little significance, as the temperature ranges from -34° to 106° F.

Vegetation, typical of the northern Great Plains, such as grama, needle, wheat, and prairie grasses, grow abundantly throughout the area. Nigger wool and bluestem grasses are dominant in the morainal hills. Cottonwood, ash, and boxelder, which are native trees, grow along the streams. Cultivated crops, including wheat and other small grains, are grown extensively on the plains. Corn and alfalfa are grown chiefly in the valleys.

Description of Coal Beds[6/]

All coal beds mined in the area are in the Fort Union formation. Several beds can be traced for many miles along their outcrops, but some have only local importance. Possibly the most continuous coal bed in North Dakota is the Coteau, which outcrops intermittently within an area about 5 miles wide and extends about 35 miles adjacent to the south side of the Souris River, from T. 153 N., R. 82 W., to the western part of T. 150 N., R. 78 W. The coal

---

5/ Andrews, D. A., Geology and Coal Resources of the Minot Region, North Dakota: Geol. Survey Bull. 906-B, 1939, pp. 43-84.

6/ Work cited in footnote 5.

Generated on 2024-09-21 17:45 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

is exposed where stream erosion has removed the cover of glacial drift and lake sediments. The Coteau bed is tentatively correlated with the Garrison Creek bed, which outcrops extensively on both sides of the Missouri River and its tributaries, 25 to 30 miles southwest.

The Burlington bed, about 200 feet above the base of the Fort Union formation and 220 to 270 feet below the Coteau bed, outcrops northwest of Minot along the valleys of the Souris River and the Riviere des Lacs and extends about 25 miles. (See fig. 2.)

The Noonan bed outcrops along the toe of the Altamont escarpment south of Noonan and Columbus (in Divide and Burke Counties, respectively) and is exploited in the Kincaid and Baukol-Noonan mines.

The Minter coal bed outcrops along Garrison and Douglas Creeks, tributaries of the Missouri River. It is 60 to 70 feet above the Garrison Creek bed.

In the area north of Hazen and Beulah, Mercer County, a thick coal bed in the upper part of the Fort Union formation, known as the Beulah-Zap bed, is commercially important.

Another important coal bed, the Wolf Creek, outcrops along the Missouri River in T. 147 N., R. 84 W. This area is near the dam site and is almost covered by Garrison Dam Reservoir. The coal is about 80 feet above the base of the Fort Union formation.

The coal in the Fort Union formation is of lignitic rank. It is brown and fibrous with many carbonized plant remains. The tough lignite does not break readily but splits easily along the bedding planes. When the coal is first exposed to air, it occasionally has a conchoidal fracture. Extended exposure causes the lignite to slack rapidly. Silicified and carbonized logs are found occasionally in the upper part of the lignite beds. The carbonized logs apparently do not affect the quality of the coal adversely, and the silicified logs can be identified readily and rejected as waste.

Near the steep-banked draws (called coulees), which cross or incise the lignite beds, or where the overburden is thin, the lignite is usually so slacked as to be valueless. Even in areas where the overburden is 30 feet or more thick, several inches to more than 1 foot of the top part of the lignite bed is often weathered to slack.

Coal beds mined at the properties examined range from 3 to 18 feet in thickness. Occasionally, the beds contain partings of bony coal, sandstone, shale, or clay. In places these partings are only a few inches thick; in others, the partings are 10 feet or more thick.

The coal beds are underlain by clay. Above the coal, especially in the Coteau and Garrison Creek beds, there is usually a blue-gray clay that contains pebbles and sand and ranges in thickness from a few inches to 20 feet. This clay is overlain by interbedded light-tan and gray sandstones and dark-gray and buff shales. These strata range from a few inches to 50 feet or

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

more in thickness, depending on how much has been eroded by glacial or stream action. Glacial till or drift and moraine material consisting of sand, gravel, boulders, and small amounts of clay and silt, unstratified and loosely consolidated, rest upon the Fort Union formation. In the northern part of the region the glacial deposits are covered in most places by a thin deposit of sediments formed by glacial Lake Souris. The total thickness of the glacial and lake deposits ranges from a few feet to 200 or more.

Consolidation of the coal seams differs slightly, and the individual coal beds show some physical differences. In some areas the coal is hard and dense and must be fractured by blasting before being loaded. At other locations the lignite is loosely consolidated and can be loaded directly without blasting.

History and Production

Lignite mining began when the first settlers arrived in the lignite-bearing section of western Dakota Territory. Immigrants generally selected farm sites near the coulees and rivers in order to have a water supply. The lignite beds were well exposed in the bottoms and banks of the streams, and farmers obtained their fuel by digging open pits and tunnels into the outcrops. This practice was so prevalent during the late 19th century that it is impossible to value an accurate estimate of the total North Dakota lignite production. According to the Thirty-Seventh Annual Report, Coal Mine Inspection Department of North Dakota (1955), the first recorded production of lignite in 1884 was estimated at roughly 35,000 tons. The annual output of lignite gradually increased, and in 1900 over 100,000 tons was mined. In 1922 production of lignite exceeded the million-ton mark for the first time and totaled 1,057,823 tons. By 1937 production had increased to 2,184,927 tons. In 1950 and 1951 it was 3,212,534 and 3,280,847 tons, respectively, the latter being the highest output recorded in the period 1884-1955. Since 1951 annual production has been near 3 million tons.

Before 1927 lignite was mined chiefly by the room-and-pillar method. This method is still practiced in North Dakota, but the number of mines using it decreases each year. Previously, shafts, slopes, and drift entries had been used to develop such mines; now most of them are developed through slopes. Since 1927 open-pit mining has been adopted gradually by the industry and now yields most of the lignite produced.

The following conditions are chiefly responsible for the change from underground to open-pit mining: Mine roofs must be supported by relatively large pillars that cannot be recovered entirely. The lignite often ignites spontaneously in the mined-out area; this also often forces abandonment of large blocks of coal. Mainly because of these conditions, only about 50 percent of the lignite developed in underground mines is extracted. The fires liberate noxious gases that are a safety hazard in underground mining.

The high productivity in tons per man-day, which resulted in low production costs, has been a major factor in developing open-pit mining procedures. Open-pit mining is currently confined to areas with a maximum cover of 70 feet, and at the mine sites the glacial material is rarely more than about

Generated on 2024-09-21 17:44 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

50 feet thick. According to the North Dakota Coal Mine Inspection Department's report, 75 mines are licensed in the State; 9 are underground, and 66 are open-pit mines.

Contour stripping is the only open-pit mining method used in the North Dakota lignite fields. Practices may differ in detail from mine to mine, but they are basically the same.

Labor and Living Conditions

The men who work at the mines usually live nearby in towns or on farms. Key personnel and supervisory officials generally live at the mines in houses rented from the company, unless the mine is very close to a town. Both the Baukol-Noonan mine and the Knife River Coal Mining Co. Beulah mine are near towns. Truax-Traer Coal Co. has provided modern camps at its Custer and Dakota Star mines, as they are far from established communities. (See fig. 3.) Rent for the company-owned houses is lower than for equivalent housing in towns - an inducement for employees to live at the mine. Utility rates also favor maintaining a home at the camp.

FIGURE 3. - Modern Camp, Dakota Star Mine, Truax-Traer Coal Co.

Labor supply and working conditions are good. Turnover is relatively low for key personnel but high for common labor, owing partly to the fluctuating demand for coal, which results in seasonal layoffs.

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Consuming Area and Freight Rates for Rail Shipment of Lignite[7 8/]

The consuming area, comprising over 100,000 square miles, includes all of North Dakota and extends into Minnesota and South Dakota. The market area extends east and southeast to localities where the cost of rail-shipped lignite and water-transported coal (from Illinois, Missouri, and Kentucky) is about equal.

Much of the lignite is shipped over 200 miles to more populous centers in the eastern part of the area. Within North Dakota freight rates for domestic-size lignite are slightly higher than for industrial-size lignite. Interstate rates per ton are the same for all sizes of prepared lignite and are lower than intrastate rates. Table 1 gives freight rates for the rail shipment of industrial lignite from various mines to selected cities.

TABLE 1. - Minimum rates for railroad shipment of industrial lignite from mines to selected cities

Mine	Destination: Grand Forks, N. Dak.1/ Distance, miles	Rate, cents: Per net ton	Per ton-mile	Fargo, N. Dak.1/ Distance, miles	Rate, cents: Per net ton	Per ton-mile	Minneapolis, Minn.1 2/ Distance, miles	Rate, cents: Per net ton	Per ton-mile
Kincaid ...	295	203	0.688	320	216	0.675	552	360	0.652
Noonan	305	216	.708	331	216	.653	563	360	.640
Beulah	351	268	.764	273	218	.799	514	347	.675
Hazen	343	254	.741	265	218	.823	506	347	.686
Garrison ..	231	231	1.000	253	242	.957	486	334	.687
Voltaire ..	191	218	1.141	213	231	1.085	446	334	.749
Zap	358	268	.749	281	218	.776	521	347	.666
Dickinson .	378	268	.709	300	218	.727	540	347	.643
Average .	-	-	.813	-	-	.812	-	-	.675

1/ Rates include ex parte 196 increase, effective Apr. 6, 1957.
2/ Rates to Minneapolis, Minn., include ex parte 206 increase.

DEVELOPMENT PRACTICE

Prospecting

Prospecting programs in the lignite field are designed to provide the data required for calculating reserves when a new mine is opened or the reserves of an operating mine are extended. In selecting the site for any mine economic factors considered include the site's nearness to railroads and markets.

7/ Bureau of Mines Staff, Washington, D. C., and Grand Forks, N. Dak., Technology of Lignitic Coals, Part 1: Bureau of Mines Inf. Circ. 7691, 1954, p. 128.
8/ McMurtrie, R., and Oppelt, W. H., Developments in Lignite Technology and Utilization: Ind. Eng. Chem., November 1956, pp. 1996-2000.

Generated on 2024-09-21 17:45 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

For open-pit mines physical factors include the depth and type of overburden, the thickness and physical characteristics of the coal bed, and the quality of the lignite. The purpose of prospecting is to delineate areas where the thickness of the overburden does not exceed 70 feet and averages about 45.

The open-pit method of mining in North Dakota is known as contour stripping. This refers to the form of the pit layout and the practice of generally following the contour of the terrain above the deposit. Often the pit design must be modified to avoid a part of the deposit that is weathered and valueless or places where stream erosion has removed a portion of it. As the coal beds are relatively flat, the depth of overburden is usually the determining factor when contour strip mining is being considered. The lignite beds are lenticular and occasionally contain clay and rock inclusions and partings; these factors must also be considered in the mine plan. Consequently, prospecting is done methodically and thoroughly, usually by drilling, to obtain the detailed data necessary to delineate and evaluate that part of the coal deposit best suited for mining.

Lignite property is acquired by mining companies from public and private owners, either by direct purchase or lease. For the most part, the land has been subdivided by the United States system of surveying public lands. Section corners and quarter corners are convenient starting points for laying out the preliminary grid for the drilling plan.

At proposed mine sites and where the extent of the coal deposit is to be determined in advance of active mines the holes are drilled first near the four corners and center of the section or subdivision. The holes are seldom drilled less than 0.5 mile apart. Data thus obtained are evaluated to direct the second phase of the prospecting plan, which consists of drilling additional holes between those where a favorable coal deposit was penetrated and between favorable and unfavorable holes to determine the limits of the deposit. The prospect holes generally are placed at or near the corners of 40-acre tracts or 0.25 mile apart.

The third and final phase of prospecting for lignite is to drill at closer intervals to outline the areas where thickness of overburden averages 45 but does not exceed 70 feet. This phase of drilling delineates the weathered and eroded areas, the parts of the deposit that might contain concretions or partings, and the areas that are too thin to mine economically. In many places the holes must be drilled on 50-foot centers to obtain the information needed before the mine-pit layout can be determined. Figure 4 shows a typical example of the drilling pattern and prospecting procedure described above.

Several types of drills have been used in prospecting. Two of them (the churn drill and mobile rotary drill) are now favored. The churn drill with a 4-inch-diameter drive shoe is used chiefly to prospect an area where it is proposed to open a new mine, especially when lignite samples are desired to determine quality.

Reserves in advance of existing lignite mines usually are determined by using a mobile rotary drill. Either a 3-7/8-inch-diameter shale bit or rock

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

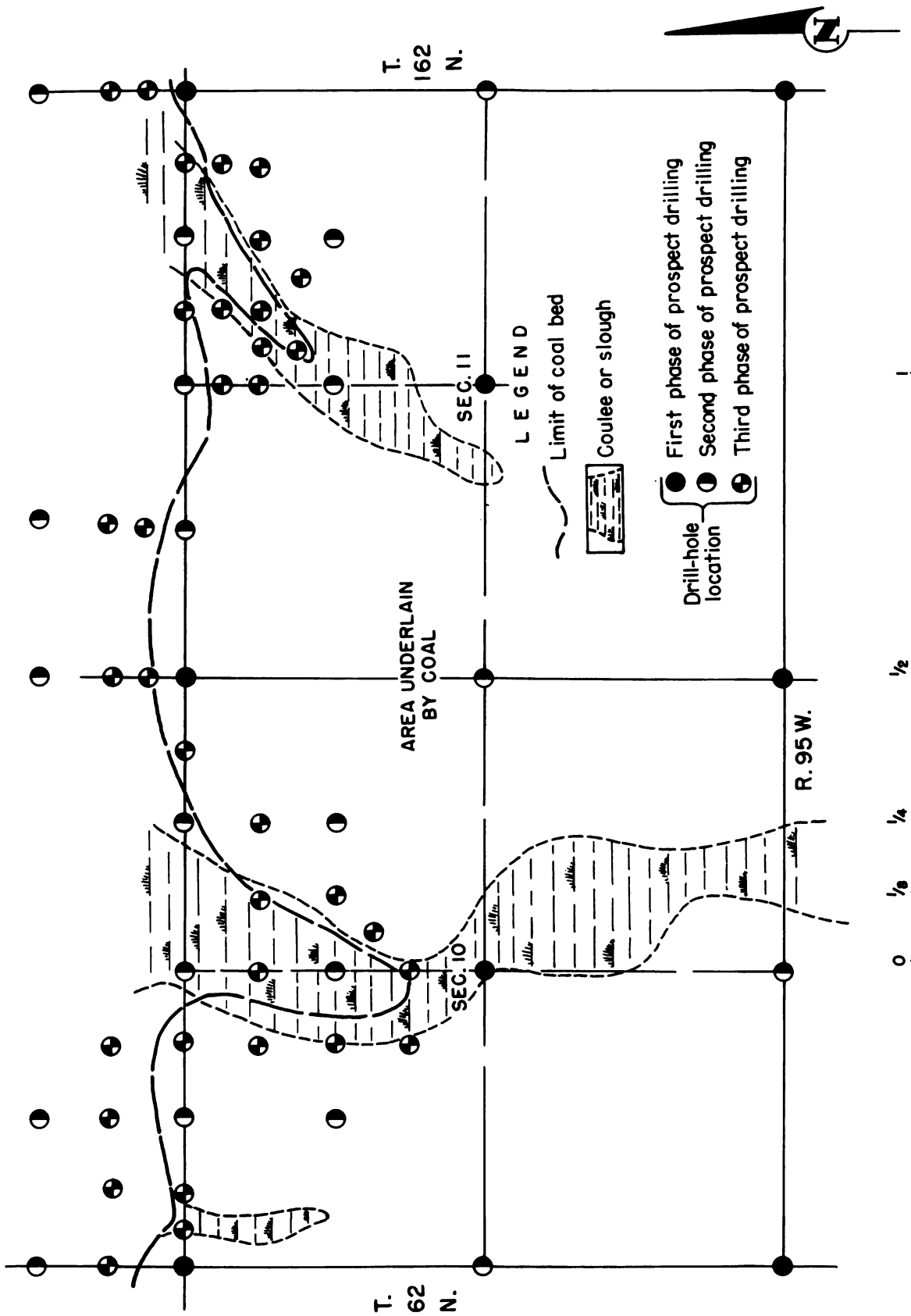

FIGURE 4. - Prospect-Drilling Sequence and Pattern.

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

bit is used, depending on the type of material encountered. The thickness and relative quality of the lignite are ascertained from the character of the drill cuttings and the action of the drill when penetrating the bed. Where resistance to penetration is strong and the drill cuttings are fine and small, the lignite is usually of good quality. Coarse drill cuttings and rapid advance of the drill usually signify that the lignite has been weathered to slack.

Churn drilling contracted to drilling companies costs approximately $1.75 per foot of hole. Rotary drilling is done by the coal-mine employees, using company equipment. Drilling programs at existing mines are usually brief and erratic in schedule, making it difficult to maintain an experienced drill crew. The grade of the lignite is broadly uniform, so that most of the information obtained by rotary drilling is reliable for the accuracy desired.

Drill-hole locations are plotted on the mine map, along with the thickness and character of the coal and overburden. At some mines elevations of the collars of the holes are given. As the coal beds are relatively flat, depth of overburden is usually the determining factor when contour strip mining is considered. Reserves are calculated from these data by the polygon or the triangle method. The customary procedure is to drill an area that will insure measured reserves equal to about 2 to 4 years of mine production. Inferred future reserves based on information obtained from trenches along the outcrop or from widely separated drill holes are generally equivalent to about 20 years of current mine production.

The large companies employ full-time engineers to survey and formulate the mine plans; small operators engage private surveyors and engineers to plan the mine layouts, after which company supervisors direct the plan of advancing the existing pits. At all mines, the development and mining advances are surveyed and mapped annually.

Sampling and Analysis

Lignite samples are obtained from churn-drill holes by driving pipe through the bed. Four-inch-diameter core samples are taken at 1-foot intervals or less, depending upon the nature of the deposit.

In rotary drilling the lignite cuttings brought to the surface by drilling fluid often are contaminated by cuttings from the overburden and for this reason are not analyzed. The relative quality of the lignite bed is determined by observing the action of the drill and the size of the cuttings during boring through the coal; this method has been discussed.

Tipple samples are obtained by taking a full cut across the stream of coal flowing from the loading chutes and booms at selected time intervals. Those chosen may range from 15 minutes to 3 hours, depending upon the degree of accuracy desired. Sometimes only one spot sample of lignite of a particular size is taken each day.

Samples from the mines and tipples operated by the Truax-Traer Coal Co. are analyzed at the company laboratory, Minot, N. Dak. The determinations

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

usually include: Moisture content, ash content, heating value, and ash-softening temperature. Occasionally, a sulfur analysis is made when a sales contract specifies a maximum sulfur content. The ultimate analysis can be made at the laboratory but is seldom required.

The following is an analysis by Truax-Traer Coal Co. of typical minus-2-inch coal taken at the Velva-mine tipple:

Condition	Moisture, percent	Ash, percent	Heating value, B.t.u./lb.	Ash-softening temperature, ° F.
As received	40.2	5.0	6,410	2,430
Dry basis	-	8.4	10,710	-
Moisture- and ash-free .	-	-	11,690	-

The smaller mining companies submit lignite samples from drill holes, mine tipples, and channels cut in the coal bed at the mine pit to the University of North Dakota School of Mines for similar analyses. Operators of coal-burning powerplants analyze the lignite received to determine adherence to specifications. Uniform-quality fuel is required to maintain efficient operation, and the analyses often are given to the lignite supplier to aid him in maintaining quality.

The Federal Bureau of Mines samples all sizes of prepared coal at each mine tipple in the lignite field at intervals of not less than 2 years. Data obtained from analyses of the samples are used as a basis for preparing Government coal-purchasing contracts and are available to all Government agencies and other interested parties. These data are kept in open files at the Denver (Colo.) and Pittsburgh (Pa.) offices of the Bureau. Both proximate and ultimate analyses are made of the samples taken during the first visit to any property. Proximate analysis, heating value, and sulfur content are determined from samples taken at subsequent visits. The ash-softening characteristics, initial deformation temperature, softening temperature, fluid temperature, and ultimate analysis are not determined after the initial visit, except on request. Selected analyses of North Dakota coals samples by the Federal Bureau of Mines are given in the Appendix.

GENERAL MINING PRACTICE

Contour strip pits are opened as near to the outcrop as physical conditions of the deposit permit. Although the lignite beds are relatively horizontal, they undulate locally and form monoclines, synclines, and anticlines. The flanks of the structures range in length from a few tens of feet to several thousand feet. The vertical distances between the crests and troughs of the anticlines and synclines range from 1 to 20 feet. The mine pit usually is started in the bottom of the syncline and advanced upgrade toward the crest of the anticline. This provides drainage for the mine water away from the working face and permits the mine equipment to operate in a relatively dry area. At the lowest part of the pit a sump is dug in the coal where the water collects. From here, the water is pumped and piped to natural drainage courses outside the mining area.

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The pit advance is directed to maintain a reasonably uniform thickness of overburden. This is accomplished by generally following the contour of the terrain and results in a meandering course. This method has been termed "contour strip mining."

The overburden is stripped by power shovel and dragline and cast from the area underlain by coal. At some mines the first strip can be continuous and follow nearly the same contour from one end of the property to the other.

More often a gully, or poor coal that must be left, or some other condition will prevent continuous stripping. In that instance a string of arcuate boxcuts of uniform widths but different lengths is excavated. When additional adjacent strips are dug and overburden becomes thicker, a continuous strip is finally developed.

At one mine an island pillar was left in the pit to protect an oil-test drill-hole site. After the initial contour strip pit has been mined out, a second strip is developed alongside the first pit and toward the main body of the lignite. Except where local conditions in the deposit force a change in the mining plan, subsequent contour strips generally parallel the course of the first strip. Overburden from the second strip is cast into the area from which the coal has been mined.

At some mines lignite is relatively unconsolidated and can be loaded directly. At others it must first be blasted. The lignite is loaded into 20-ton-capacity trucks and transported to a centrally located tipple to be prepared for the market. The crushed and screened lignite is loaded into railroad cars (40- to 70-ton capacity) or trucks.

Stripping

In the early period of development of the North Dakota lignite fields a few smaller companies hired independent contractors to strip the overburden. In 1957 most companies stripped overburden with company-owned equipment.

At the mines overburden is 30 to 70 feet thick. Stripping shovels, draglines, and tower excavators are used to remove it. Single units, shovels, or draglines are employed to strip overburden less than 40 feet thick. Combinations of the different types of excavating machines remove overburden thicker than 40 feet.

In some mines, two recoverable lignite seams occur at different stratigraphic levels. Stripping overburden at these mines requires considerable maneuvering of the equipment and complicates the procedure.

At some pits the overburden contains rock lenses that range in thickness from a few inches to as much as 6 feet and are as much as 12 feet wide and several huddred feet long. Usually these lenses are found in the upper part of the predominantly clay overburden.

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The stripping procedure at one mine is as follows: The dragline removes the overburden down to the rock lens, in which blastholes are then drilled with a jackhammer. The holes are commonly started with a 2-1/8-inch bit on a 2-foot steel, followed by a 2-inch bit on a 4-foot steel, and finished with a 1-7/8-inch bit on a 6-foot steel. Compressed air is supplied by a portable compressor hauled by a pickup truck.

The size of the rock lens determines the spacing of the blastholes, although they are usually on 5-foot centers. If the lens is wide enough, a box spacing is used. In a small lens one hole is often sufficient to break the rock, so that it can be handled by the stripping equipment. Each hole is charged with 6 sticks of 1-1/4- by 8-inch, 35-percent Monable AA dynamite and tamped with clay. The charge is detonated by electric caps, using magnetos or special blasting devices connected to the power source of the stripping machinery. The cost of the explosives for this operation averaged about $0.005 per ton of coal produced.

The weathered and contaminated slack at the top of the seam is pushed within reach of the stripping shovel or dragline by a bulldozer and spoiled with the clay and rock overburden. The top of the coal is then thoroughly cleaned and prepared for mining by a scraper loader. (See fig. 5.)

Climatic Conditions Affecting Operations

Normal snowfalls are readily removed from the roads and working areas by a patrol grader and bulldozer. Portable snow fences are sometimes installed at strategic points along the haulage roads and pit rims to stop snow from drifting. The area near the working dragline is cleared of snow immediately after a storm, so that the machine can be maneuvered without building up a compacted snow mass under the dragline tub. Severe snowstorms have occasionally caused the mines to be idle for a few days, usually because the railroads cannot furnish cars to the tipples, especially when the snowstorm is accompanied by high winds that cause drifts and block the railroad cuts.

Clay freezing to the dippers adversely affects the efficiency of the stripping machines. The clay builds up inside the dipper to such an extent that it reduces the dipper's capacity, and the machine must be stopped occasionally to remove the accumulation by heating. The Fort Union formation is predominantly clay and contains too little shale and rock to clean the clay from the dipper.

Several heating methods have been tried to prevent freezing clay from adhering to the dippers. One method used is to heat the dipper periodically by placing it upon a pile of burning ties saturated with waste oil. Oil-burning torches directed onto the dipper also have been used, but the uneven heating caused considerable cracking. Calrod heater strips and plates are used at some mines to heat the dippers and have proved fairly satisfactory.

Truax-Traer Coal Co. has been experimenting with another heating method - pumping hot antifreeze fluid through metal tubes that are secured within the dipper shell. The liquid is heated by an oil-burning torch operating within a small chamber containing a heating coil. Operation of the torch is

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

controlled by a thermostat, which is set to regulate the temperature of the fluid circulated continuously through the tubes. A similar dipper heater was installed and operated satisfactorily in the winter of 1955 at the Custer mine, and another heating unit of this type was being assembled at the Kincaid mine in the fall of 1956.

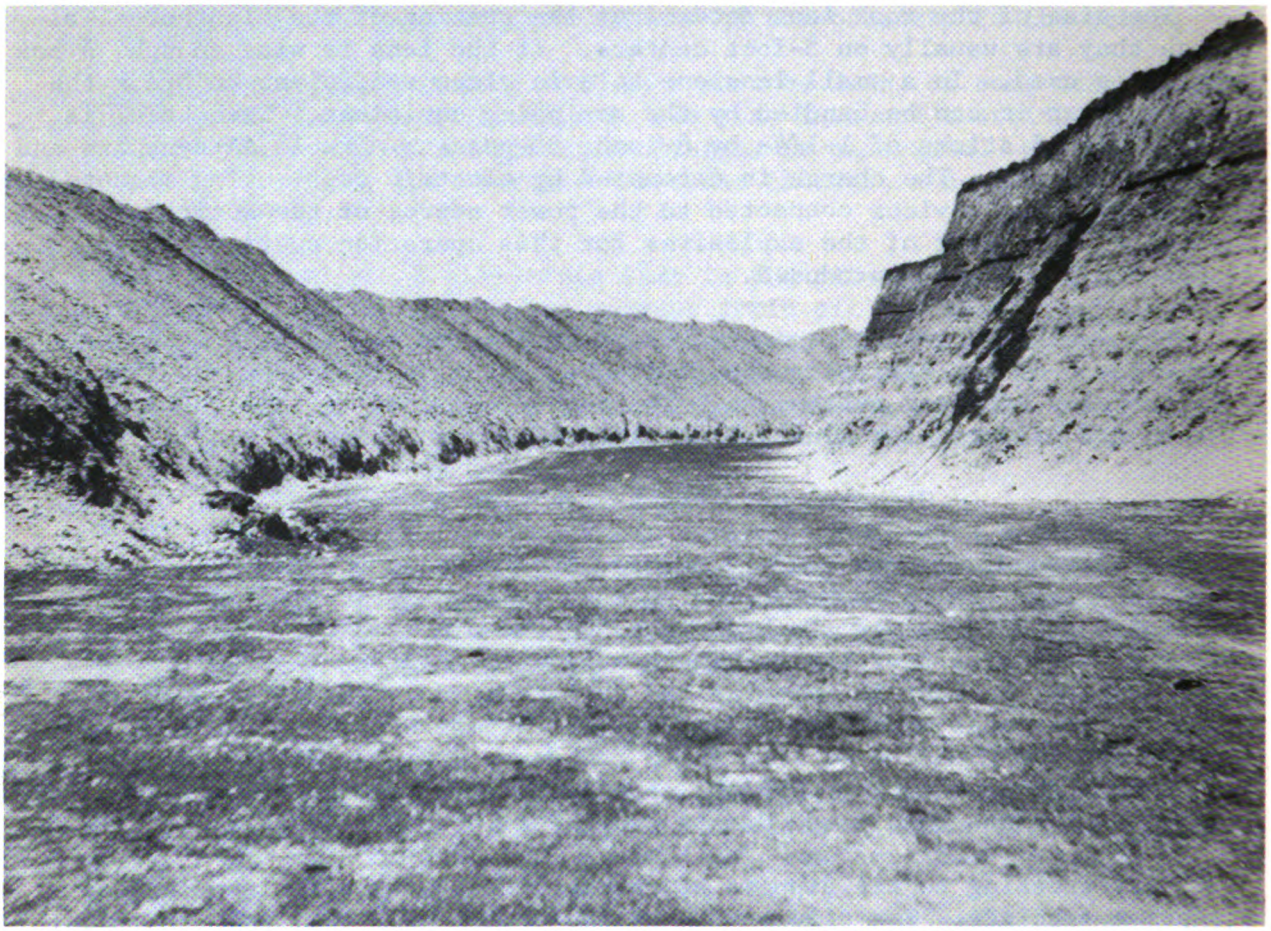

FIGURE 5. - Lignite Bed Stripped and Cleaned for Loading.

Drilling and Blasting Practice

Wagon drills, often made by the company, are used predominantly to drill the coal. (See fig. 6.) The drills usually are mounted on pneumatic-tire, 3-wheel carriages. Generally, they are gravity-fed drills that utilize the weight of the motor and gearbox, but occasionally they are fed manually. The tool stems consist of 2-1/2-inch-diameter, flat-pitch coal augers fitted with either throwaway or tungsten carbide insert bits. The rotary drills are driven by gasoline or electric motors. Vertical drill frames are constructed to accommodate about 12 feet of effective auger. When the lignite deposit exceeds

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

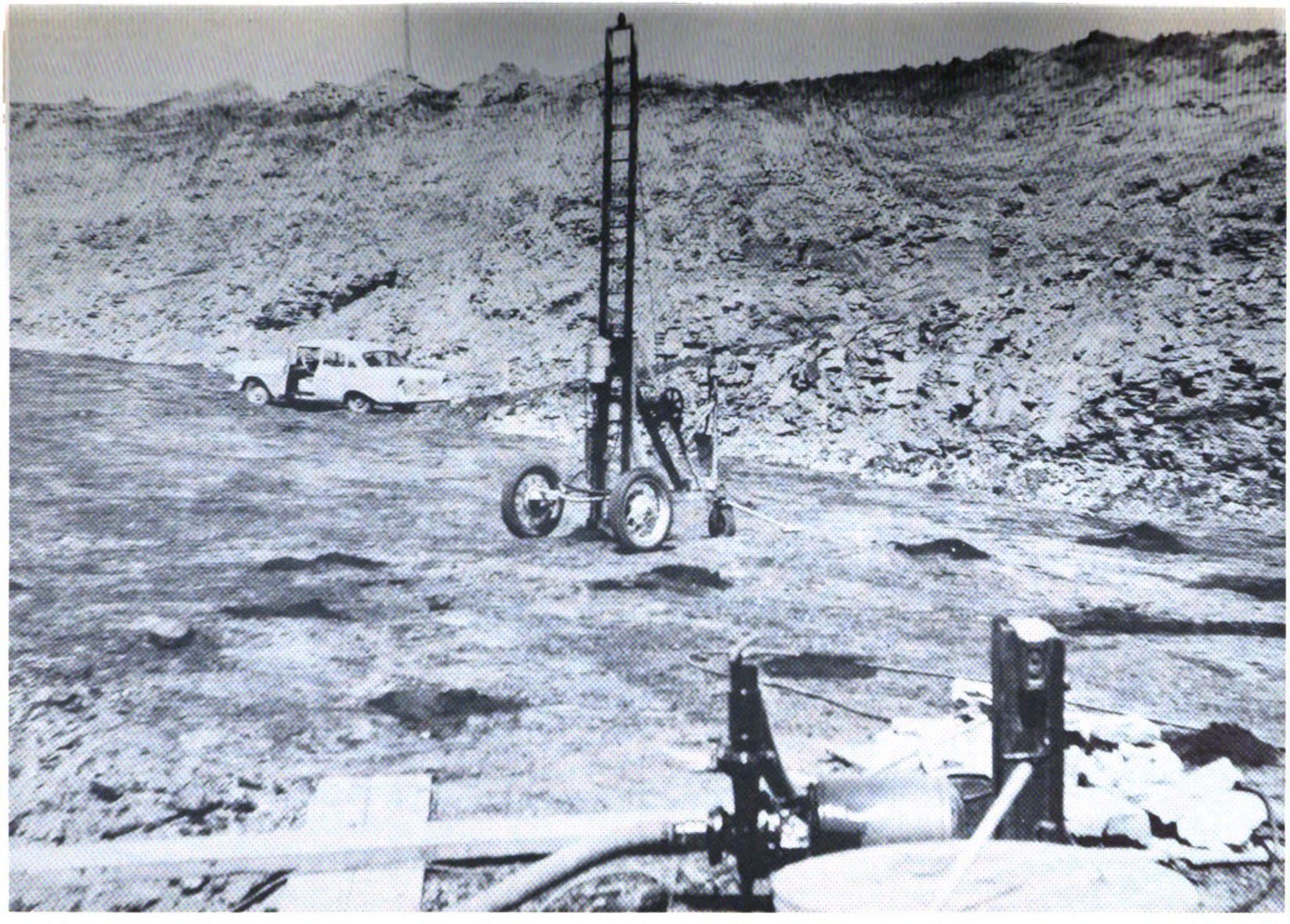

FIGURE 6. - Wagon Drill Used to Drill Lignite for Blasting (Drill Cuttings Indicate Drill-Hole Pattern), Dakota Star Mine, Truax-Traer Coal Co.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

12 feet in thickness, additional 4-foot sections of the auger steel are added to complete drilling of the thicker bed. Blastholes are drilled to the bottom of the coal. The explosive charge is placed in the bottom of the hole and tamped with clay.

Drillholes are spaced at 10- to 12-foot centers, depending upon the thickness of the coal bed. In beds thinner than 10 feet the blastholes are spaced at intervals equivalent to the thickness of the coal. The box diagram is favored for the drillhole pattern, but the alternately spaced or triangular arrangement is also used.

Five to nine sticks of explosive are used for each hole, depending upon the type of coal prepared for the market or its toughness. At some mines the explosive is detonated with electric blasting caps; at others MS-delay electric blasting caps are used. When delay caps are used, three rows of drill holes are usually fired for each round. The row of holes near the previously broken face is detonated by MS-50 electric blasting caps; the second and third rows toward the solid are detonated by MS-75 and MS-100 delay caps, respectively.

Several types of explosives are used for blasting. Two of the more common types are Lump Coal-C and Stripkolex, permissible explosives detonated by electric blasting caps with 10-foot-long lead wires which are fired, 5 or 6 holes at a time, by a 50-cap blasting machine.

Slightly more than 1 day's mine production is drilled and blasted before mining. Where the coal bed ranges from 10 to 14 feet in thickness and averages 12 feet, a drill crew of 2 men can drill 40 to 60 holes in wet coal and 100 to 120 holes in dry coal in one 7-1/4-hour shift. It is estimated that 1 pound of explosive breaks an average of 6 tons of coal.

Loading

After stripping and blasting, the coal is loaded by electric-powered shovels into diesel-powered trucks. (See fig. 7.) The shovels operate in the bottom of the pit from which the coal is being loaded. They load the coal into trucks that travel on top of a solid coal berm or in the bottom of the pit, provided it is dry. The width of the exposed coal varies from mine to mine. If the coal seam contains water, the underlying clay stratum becomes soft, and haulage roads constructed in the pit bottom are impassable. When this condition exists, a berm of solid coal is incorporated in the pit design to provide an all-weather access road.

Percentage of Extraction

It is estimated that overall extraction of lignite by stripping in North Dakota is about 70 percent. About 90-percent extraction of the marketable stripped coal is realized. The largest block of coal not mined is the narrow strip or fender of lignite left along the toe of the spoil pile to prevent waste from contaminating the mined coal. Also, a thin blanket of lignite usually is left in the bottom of the pit to insure that the underclay will not be mixed with the lignite.

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

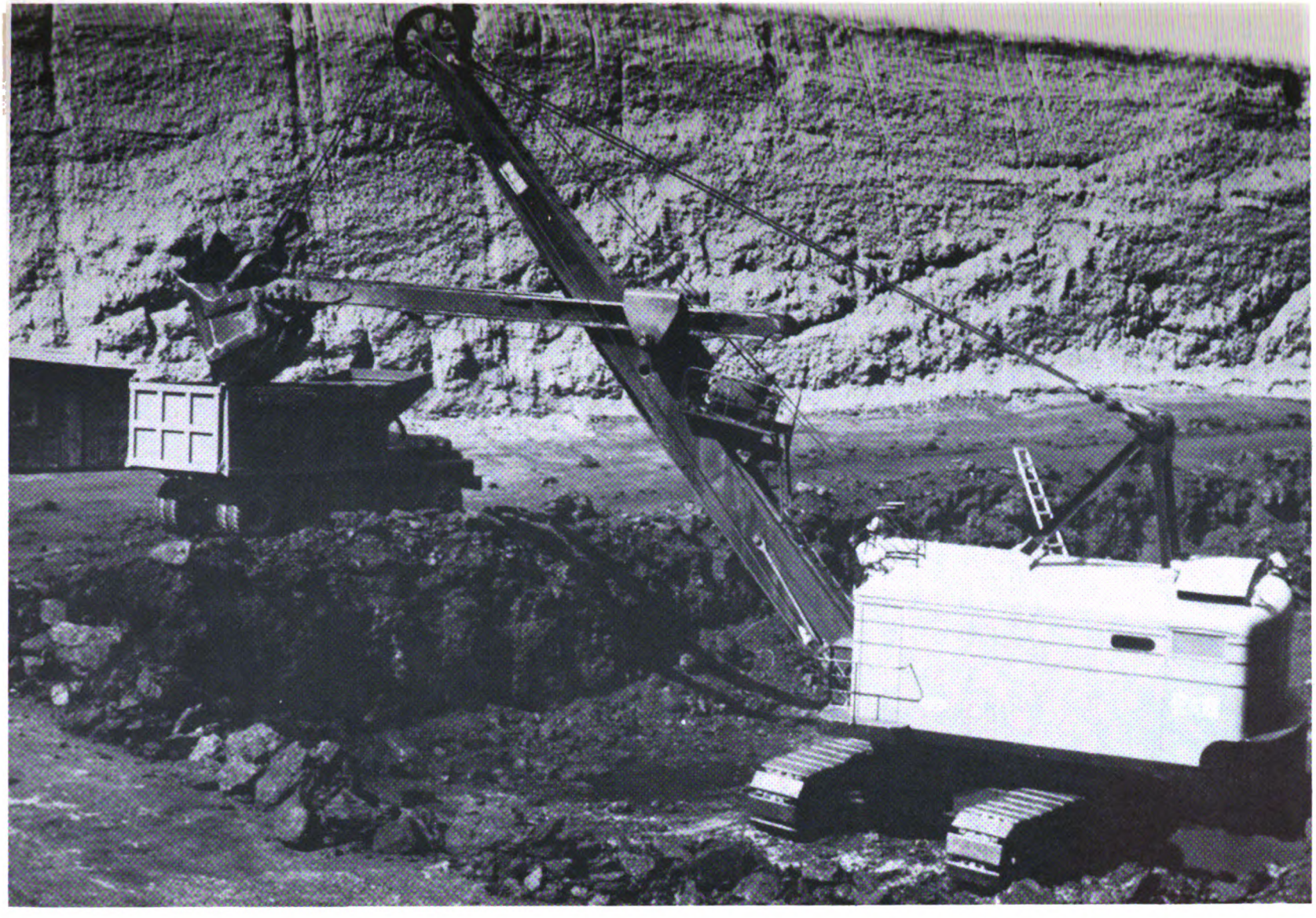

FIGURE 7. - Loading Lignite With Power Shovel Into Rear-Dump Truck, Beulah Mine, Knife River Coal Mining Co.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Drainage

Coal beds and sandstone lenses in the Fort Union formation are known to be aquifers in the area. Flowing wells are found at some locations when the beds and lenses are drilled along the edge of the escarpment south of the Souris River. These beds have produced artesian water at depths of 100 to 550 feet.

According to Simpson:[9/]

> The water, which rises in wells to the surface in small weak flows, seems to derive its hydrostatic pressure more from the higher ground level beneath the escarpment, which causes a slow general downward percolation of the water, than from the elevation of water in the bed that is tapped.

In some places the coal and sandstone have little or no water. Mines in those localities are drained by intermittent or continuous pumping, as required.

Generally, mining is advanced upgrade, and the water produced at the face is ditched to a sump. The size of the sump may range from a hole with dimensions of a few feet to one as wide as the pit and several hundred feet long. The water is pumped from the sump and piped either over the highwall or spoil pile to the nearest natural draw draining away from the mine area. The maximum static head seldom exceeds 80 feet. It is necessary at times to dig ditches to divert mine and surface waters away from the pit when natural drainage is lacking.

Pumping stations are constructed usually by dumping spoil into the mined-out part of the pit used for the sump. This pile of waste is leveled and forms a small peninsula protruding from the coal-berm roadway into the sump. In order that the pumps will have a relatively low-suction head, the top of the fill is graded so that its elevation is only a few feet above the high-water level in the sump. A station of this type is easily accessible and provides a stable footing for workers who maintain or repair the pumps. (See fig. 8.) Pumps may also be mounted on rafts constructed of wooden frames and steel drums. The discharge lines are plastic or rubber hose, iron pipe, or combinations of these; depending upon conditions.

At some pits small self-priming pumps, operating intermittently and automatically, handle the mine water. At other mines the water is controlled by continuous pumping from large sumps. The pumps range in size from 1.5-inch discharge pumps driven by gasoline motors to 6-inch discharge centrifugal pumps driven by 40-hp. electric motors. Most of the pump motors operate on 220-volt, a.-c. motors, but a few of the larger pumps that discharge through long pipelines are driven by 440-volt, a.-c. motors.

9/ Simpson, H. E., Geology and Ground Water Resources of North Dakota: Geol. Survey Water Supply Paper 598, 1929, pp. 250-262.

Generated on 2024-09-21 17:46 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

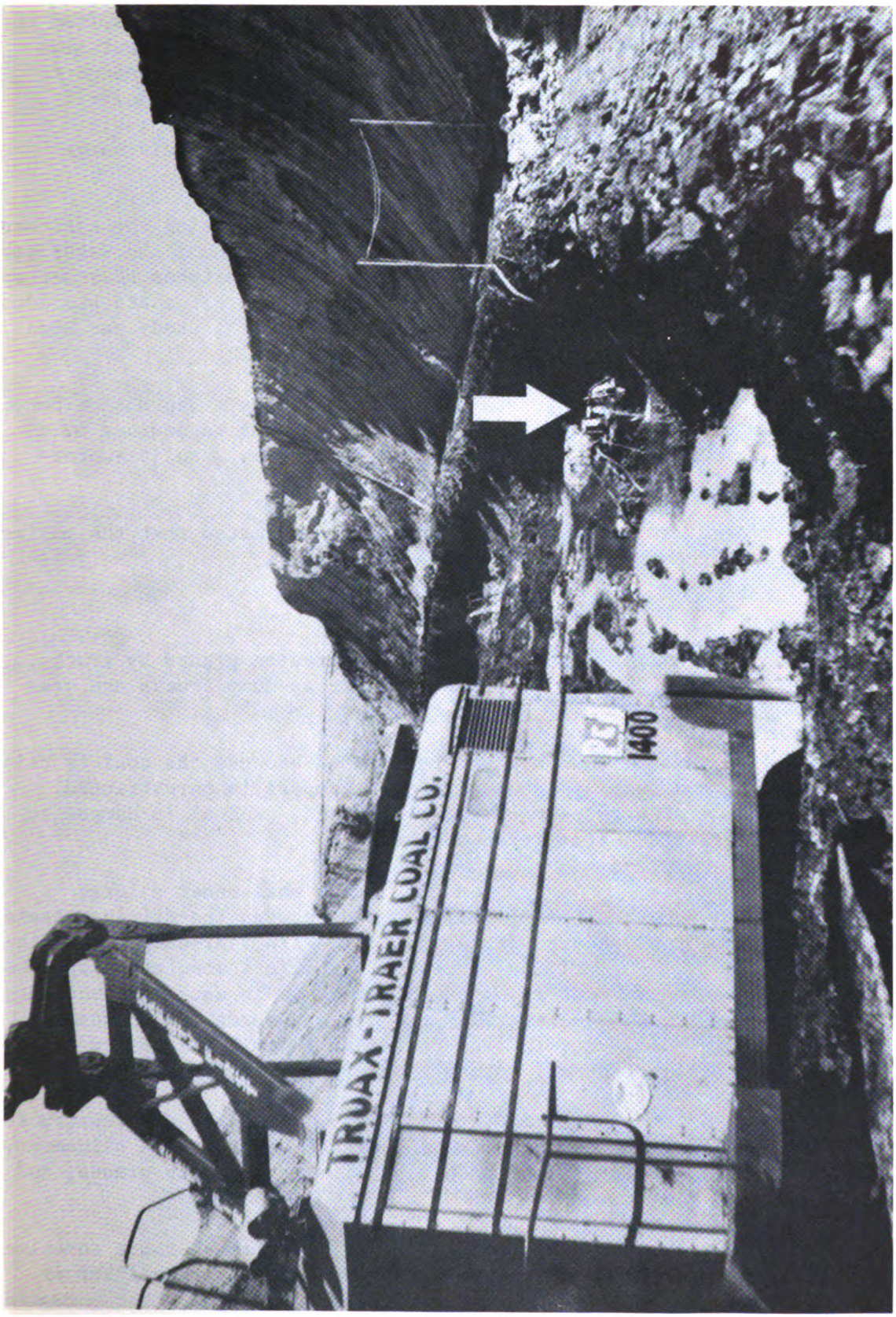

FIGURE 8. - Pump Station in Pit Behind Loading Shovel; Trailing Power Cable Supported Above Haulage Road by Bridge Constructed of Pipe. (Arrow Points to Pump Station.)

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

At the east end of the Velva mine a large volume of water flows from the coal seam. The water accumulates in the sump formed by the mined-out area at such a rate that it is not economical to provide a pump large enough to handle the inflow. Present practice is to pump continuously for several months in an area before it is mined in order to lower the water table. A sump is constructed at the lowest elevation, and 6- and 4-inch discharge pumps are installed. (See fig. 9.)

A study is being made to evaluate this method of dewatering the coal bed at Velva. Test wells are being drilled so that the drawdown of the water table by pumping can be measured. Excavation of large pits and ditches to intercept the underground flow in advance of the mine workings is an alternate procedure, but this action doubtless will be deferred until the present study has been further advanced.

Occasionally the coal bed undulates locally and forms a depression between the working face and the sump. When the depression cannot be drained by a ditch, the water is pumped into the main sump by portable, gasoline-motor-driven pumps.

Pumping cost data are not available, but it is estimated that the maximum power cost is about 2 cents per ton of mined coal.

Haulage

Coal is transported from the pits to the preparation plants by trucks. Bottom-dump semitrailers are used at 5 mines, and rear-dump trucks are used at 1 mine.

The bottom-dump semitrailers are generally used because the coal is relatively free flowing, and dumping into drive-over hoppers is unrestricted. (See fig. 10.) At one mine rear-dump trucks are used, as coal is dumped at the preparation plant into a restricted hopper.

The trucks are subject to severe loading impact when under a large shovel. With semitrailers the load is distributed between the driving wheels of the tractor and the rear wheels of the trailer. With rear-dump trucks the load is concentrated over the driving wheels. This offers some advantage when it is necessary to drive over water-softened roadbeds. In each instance large tires are used to aid traction. Generally the haulage roads are reasonably level, permitting high-speed travel. The bottom-dump semitrailers are Euclids, and the rear-dump trucks are Macks; both are powered by 200-hp. diesel engines.

Main haulage roads from the immediate vicinity of the pit are constructed by first grading the surface to conform to a designed and surveyed alinement. The road plan provides for long, smooth curves, eliminates steep grades, and assures good drainage.

Several materials are used for road surfacing. Permanent roads sometimes are surfaced with gravel or scoria (a name given to the natural clinker or calcined clay formed where coal has burned near the outcrop). Other permanent

Generated on 2024-09-21 17:49 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

FIGURE 9. - Sump and Pump Station Used to Predrain Lignite Bed in East Section of Velva Mine, Truax-Traer Coal Co. (Arrow Points to Sump and Pump Station.)

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

roads are surfaced with pit-run gravel or scoria mixed with the subgrade material as a binder. Still other permanent roads are surfaced with a mixture of 1 part of clay and 3 parts of scoria or gravel. The mixture is prepared in windrows by patrol graders, spread evenly, and compacted upon the roadbeds. A large, tractor-drawn roller is used to crush and compact this surfacing material.

FIGURE 10. - Maintained Haulage Roads Permit Fast Travel. Truck Returning to Kincaid Mine Pit After Dumping Load at Tipple.

Another method of road surfacing requires laying a 6-inch course of compacted raw clay upon the subgrade, followed by a course of compacted gravel. Roads constructed by this method are reported to be extremely resistant to attack from normal precipitation and even withstand severe rains or snowstorms with little or no damage. Temporary access roads are built to less exacting specifications and usually are surfaced with a single course of scoria, gravel or cinder, and clinker obtained from the powerplants.

Normally roads are built wide enough for two-lane traffic. Where high speeds can be attained, roads are made wider to assure safe passing. Where topography is favorable, the pit roads are separated and permit one-way travel.

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The ramps into the pit are initially short, steep approaches about 500 feet long and have as much as a 10-percent grade. Ramps through the highwall side of the pit remain constant in grade and length until the stripped coal accessible from them has been mined. (See fig. 11.) Stripping of the next contour destroys much of the ramp, and a new one must be constructed. The first ramps built on the spoil-pile side of the pit have about the same specifications as those on the highwall side. As each new contour strip is developed, this ramp increases in length and decreases in grade. (See fig. 12.) These ramps are graveled and maintained in good condition; otherwise, they would become bottlenecks in the haulage system.

Haulage roads in the pit bottom are either on top of the coal berm or traverse the exposed underclay. The pit roads are relatively rough, and only a minimum of maintenance is provided to keep them in shape for the slow-moving traffic. The pit access ramps generally are built a maximum of 1,500 feet apart. Where practical, the haulage road is constructed as a loop so that trucks, shuttling between the pit and the tipple, travel a continuous route. This arrangement is usual when mining close to the tipple. Where mining has extended several miles from the tipple, a single, wide haulage road is constructed. Near the mine and tipple, small loop roads are constructed to aid travel through the relatively congested areas.

The mines are in areas with gently rolling or nearly flat topography. Consequently, main haulage roads seldom have adverse grades of more than 1 percent, and these usually extend only a fraction of a mile. Trucks can travel safely 35 to 40 miles per hour. A few trucks powered by gasoline motors were used when truck transportation was first adopted in the lignite fields. They were replaced by diesel-powered trucks because diesel fuel costs about one-third as much as gasoline. At one mine the cost of fuel used in hauling coal averaged $0.02 per ton-mile.

Preparation

Crushing and Screening

Tipples in the North Dakota lignite fields are designed primarily to produce specific sizes of coal. Coal prepared before 1930 was in sizes larger than 2-inch because it was used chiefly for domestic purposes and in large heating furnaces in schools, hotels, and public buildings. At that time the minus-2-inch coal was generally a waste product. Since 1930 there has been a gradual increase in the use of smaller coal in industry, so that in 1956 about 70 percent of the prepared coal sold was minus-2-inch.

Coal sizes prepared for market generally are classified as lump, furnace, stove, stoker, crushed stoker, and industrial screenings. Standard sizes have not been adopted for these classifications; thus, tipple products of the same name may vary in size from mine to mine. The following are market sizes of coal products having the same name:

Generated on 2024-09-21 17:45 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

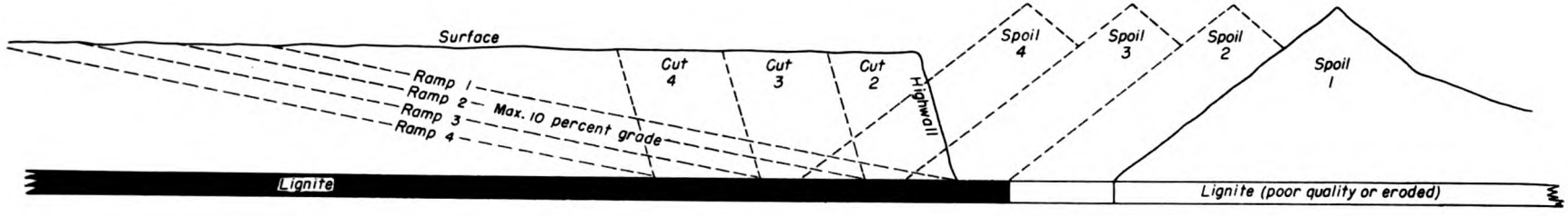

FIGURE 11. - Sketch Showing How Ramps Are Cut in Overburden on Highwall Side of Pit to Provide Access to Each Consecutively Mined Strip of Lignite.

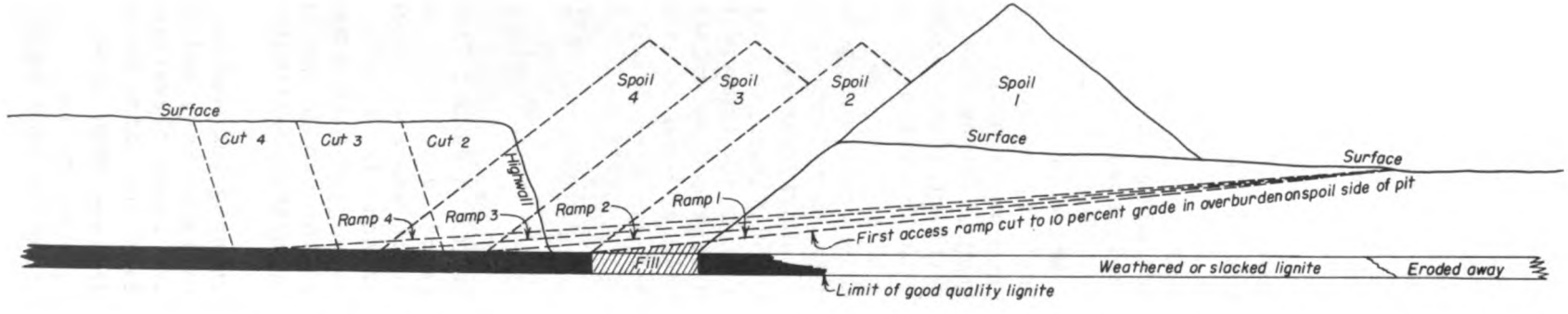

FIGURE 12. - Sketch Showing How Ramps Are Constructed Through Spoil Piles to Provide Access to Each Consecutively Mined Strip of Lignite.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Size, inches:	Classification
Plus 8 or 6	Lump.
8 by 4 or 6 by 3	Furnace.
4 by 2 or 3 by 2	Stove.
2 by 1-1/2 or 2 by 1	Nut or stoker.
Minus 2	Crushed stoker.
Minus 2	Industrial screenings.

The Dakota Star mine tipple, one of the larger preparation plants in the area, produces about 90 tons of furnace coal, 40 tons of stove, 80 tons of stoker, and 100 tons of minus-2-inch natural per hour. "Minus-2-inch "natural" is a term used in the North Dakota lignite industry to describe the product screened from run-of-mine lignite before crushing. When the natural and crushed (minus-2-inch) coal is combined, the tipple can produce 400 tons of coal per hour. When stoker coal is produced, about 20 tons of minus-1/2-inch coal is made, which is blended with the minus-2-inch natural and sold to the powerplants. Under favorable conditions over 4,000 tons of lignite has been prepared by this tipple in one 7-1/4-hour shift.

Most of the tipples are designed so that the different sizes may be mixed to suit the demands of the customer. Fines are marketed by all the mines except one; there the waste product is stockpiled. Natural lignite fines are generally higher in ash content than the larger sizes of lignite and inferior in other qualities. Therefore, once this fine lignite is stockpiled, it is seldom reclaimed.

At most mines the tipple machinery has been replaced gradually to keep pace with the changing demands in coal sizes. An exception is the Velva mine, where it was advantageous to build a new preparation plant to replace the obsolete one. The new tipple was built near the center of the mining area, and the savings in coal-hauling costs helped to defray the costs of the plant. (See figs. 13 and 14.)

The preparation plants do not include mechanical cleaning. Most deleterious material (silicified logs, clay, and sandstone partings) in the lignite beds could be rejected readily from the crushed product by bone pickers. However, only one company has picking tables in its preparation plant. The small amount of bony coal and rock in the coal after it has passed over the picking tables cannot be removed economically by washing.

Because lignite is tough and fibrous, it is difficult to reduce to uniform size. The primary breakers that handle lignite lumps, some several feet in diameter, are usually 30- by 72-inch, double-roll breakers, fitted with offset and meshing cone teeth. The action of the breaker - a combination of crushing, tearing, chopping and shredding - reduces the lignite to a size and form that can readily be reduced further by the secondary crusher. Double-roll, 24- by 48-inch crushers with cone teeth are used for secondary reduction. Some recently constructed tipples, however, have 30- by 60-inch (and larger) double-roll crushers, and one tipple has a large single-roll crusher for secondary reduction. As the crushers can be adjusted to produce various sizes of

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:42 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

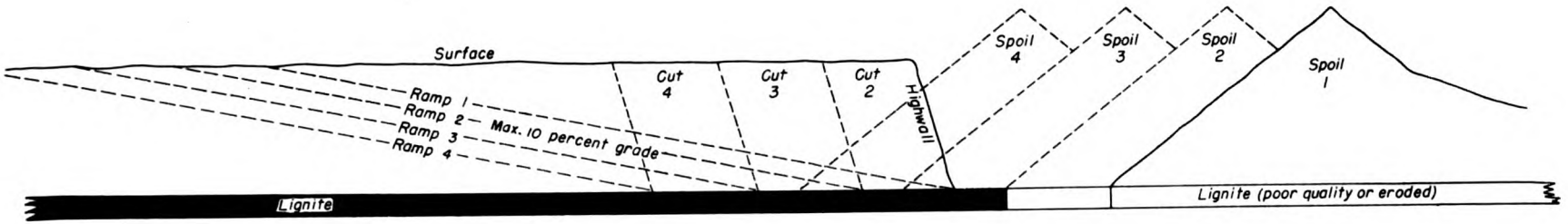

FIGURE 11. - Sketch Showing How Ramps Are Cut in Overburden on Highwall Side of Pit to Provide Access to Each Consecutively Mined Strip of Lignite.

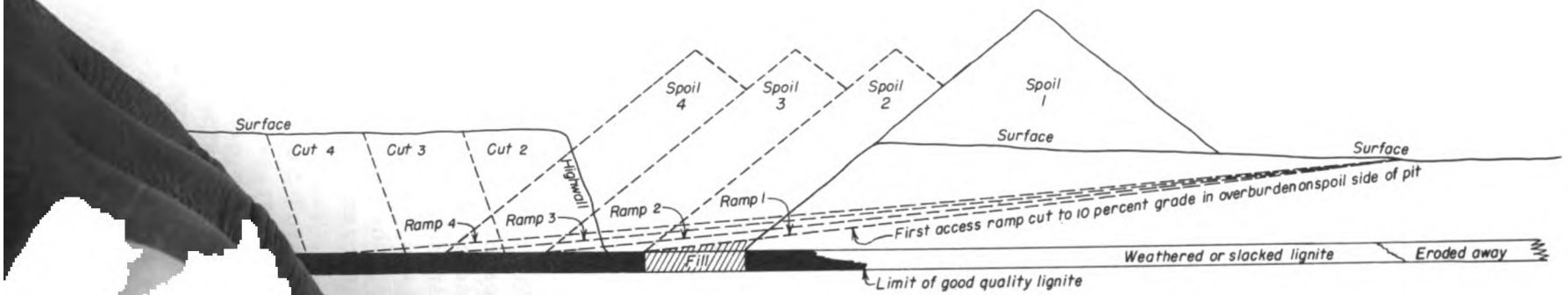

FIGURE 12. - Sketch Showing How Ramps Are Constructed Through Spoil Piles to Provide Access to Each Consecutively Mined Strip of Lignite.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Size, inches:	Classification
Plus 8 or 6	Lump.
8 by 4 or 6 by 3	Furnace.
4 by 2 or 3 by 2	Stove.
2 by 1-1/2 or 2 by 1	Nut or stoker.
Minus 2	Crushed stoker.
Minus 2	Industrial screenings.

The Dakota Star mine tipple, one of the larger preparation plants in the area, produces about 90 tons of furnace coal, 41 tons of stove, 80 tons of stoker, and 100 tons of minus-2-inch natural per hour. "Minus-2-inch "natural" is a term used in the North Dakota lignite industry to describe the product screened from run-of-mine lignite before crushing. When the natural and crushed (minus-2-inch) coal is combined, the tipple can produce 400 tons of coal per hour. When stoker coal is produced, about 21 tons of minus-1/2-inch coal is made, which is blended with the minus-2-inch natural and sold to the powerplants. Under favorable conditions over 4,000 tons of lignite has been prepared by this tipple in one 7-1/4-hour shift.

Most of the tipples are designed so that the different sizes may be mixed to suit the demands of the customer. Fines are removed by all the mines except one; there the waste product is stockpiled. Natural lignite fines are generally higher in ash content than the larger sizes of lignite and inferior in other qualities. Therefore, once this fine lignite is stockpiled, it is seldom reclaimed.

At most mines the tipple machinery has been changed gradually to keep pace with the changing demands in coal sizes. An exception is the Velva mine, where it was advantageous to build a new preparation plant to replace the obsolete one. The new tipple was built near the center of the mining area, and the savings in coal-hauling costs helped to defray the costs of the plant. (See figs. 13 and 14.)

The preparation plants do not include mechanical cleaning. Most deleterious material (silicified logs, clay, and carbonaceous partings, in the lignite beds could be rejected readily from the run-of-mine product by some plants. However, only one company has provided a preparation plant. The amount of clay coal and rock removed by washing, as it has passed over the tables [illegible]

Generated on 2024-09-21 17:46 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

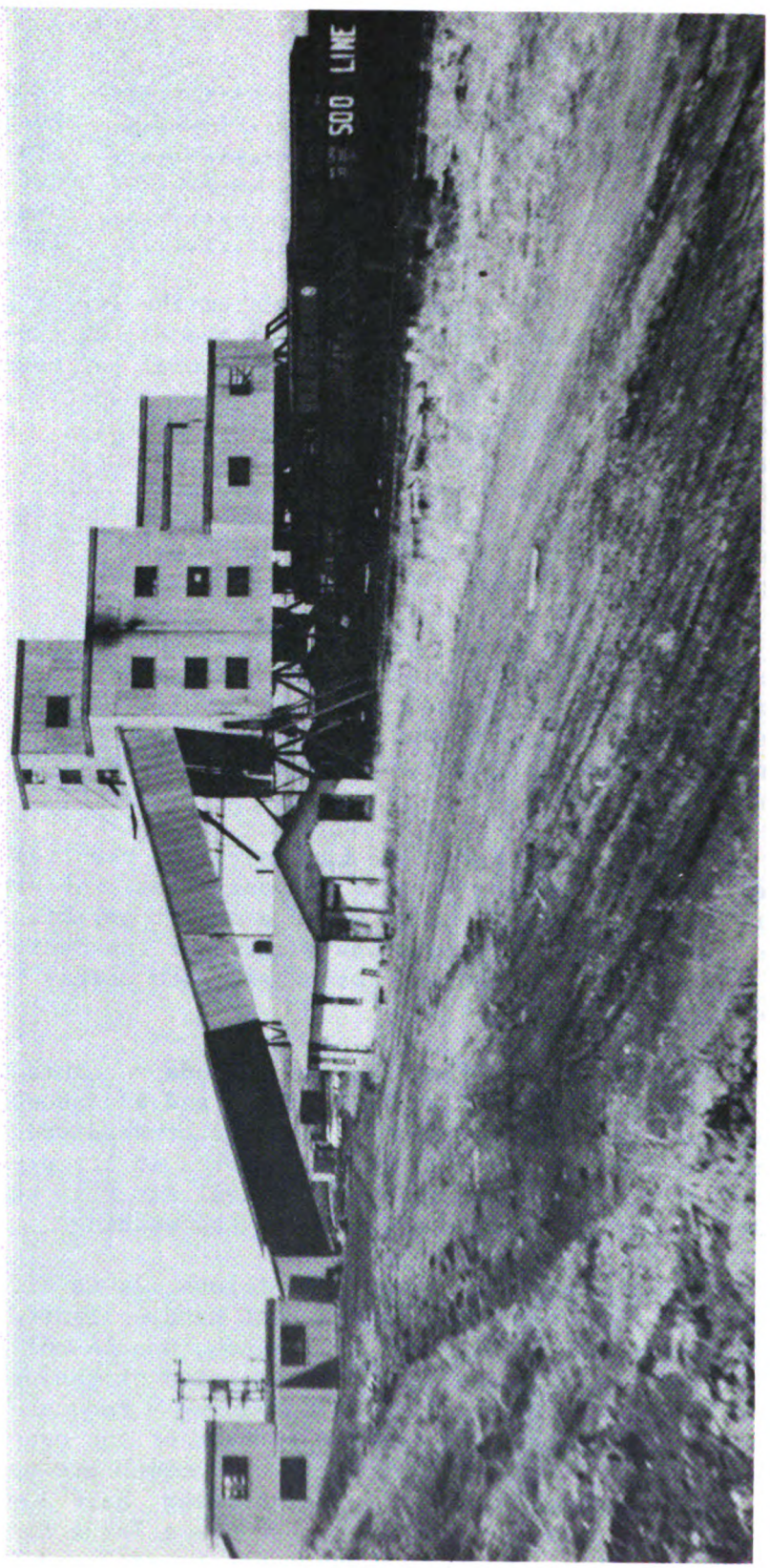

FIGURE 13. - Velva Mine Tipple, Truax-Traer Coal Co.

Generated on 2024-09-21 17:46 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from
THE OHIO STATE UNIVERSITY

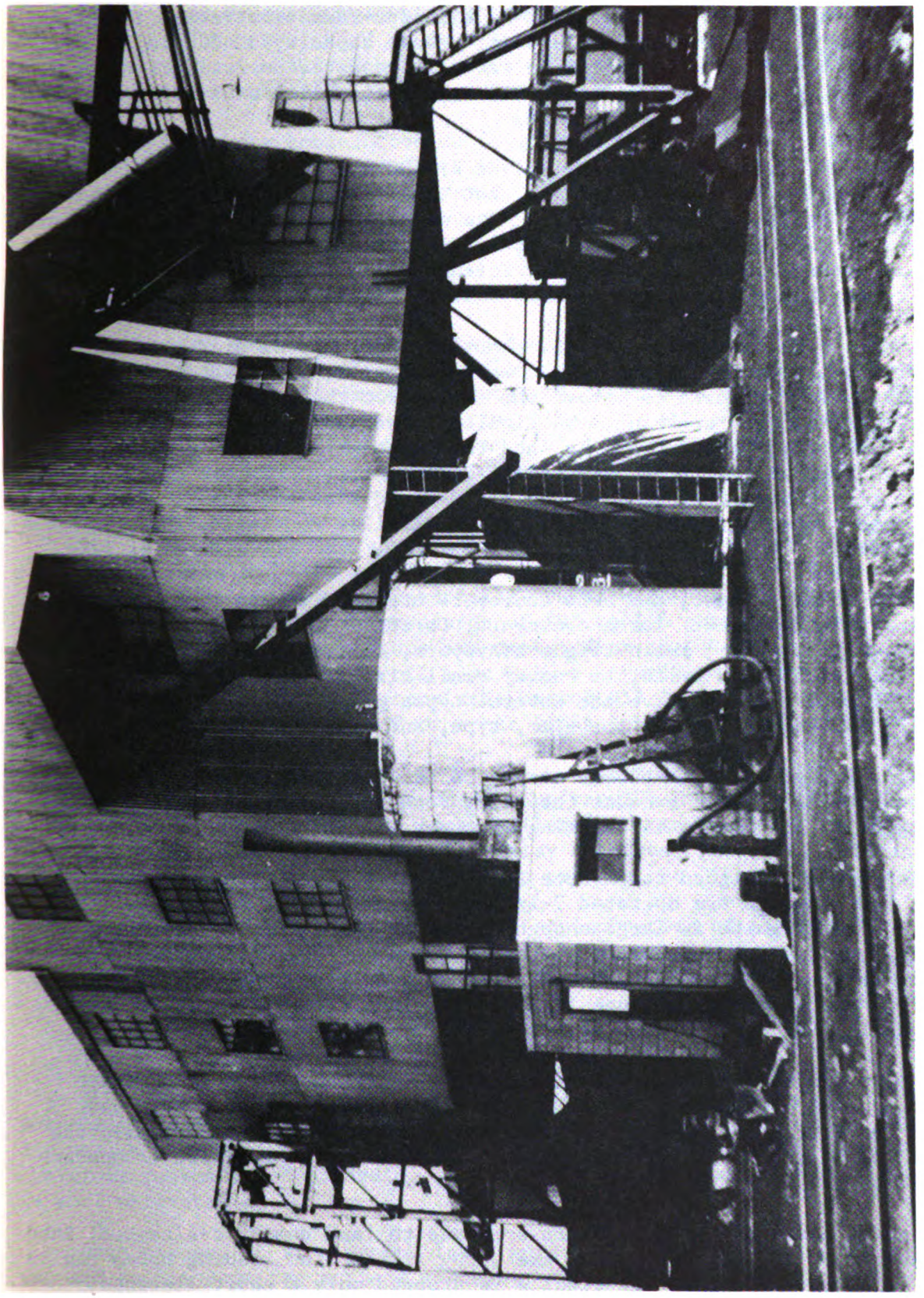

FIGURE 14. - Storage Tanks for Spray Oil, Heater, and Pumphouse, Velva Tipple, Traux-Traer Coal Co.

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

coal, their capacities vary according to the size-reduction ratio. Most secondary crushers, 24 by 48 inches in size, have a capacity of 300 to 350 tons per hour, provided the size-reduction ratio is adjusted to 2. This ratio is about 30 to 50 percent lower than that for crushing bituminous coal, for which the crushers were originally designed.

Primary breakers are commonly driven by 100-hp. electric motors. Older secondary crushers have 50-hp. motors, but some recently installed, larger crushers are driven by 75-hp. motors. The motors appear oversized, but the toughness of the lignite and the freezing conditions in winter require motors having additional power to operate efficiently. Most electric motors operate at 440 volts, but a few special motors operate at 220 volts.

Shakers with changeable screens that have openings of different size are used for primary sizing of lignite. Smaller screens, vibrated electrically or mechanically, are used to remove the fines from the crushed stoker sizes. Usually, in secondary crushing, the lignite is passed over the vibrating screens immediately after crushing, and the oversize is conveyed back to the crusher and recrushed. Often a piece of lignite will pass through the crusher several times before it is reduced to the desired size and shape. At some tipples two vibrating screens are placed in parallel to provide enough screening capacity.

Apron, chain-flight, and belt conveyors are used in the tipples. The usual installations are: Apron conveyors, to convey and elevate mine-run and large sizes of lignite; chain-flight conveyors, to transport and elevate intermediate-size coal; and belts, to convey small sizes. Motors, ranging from 5 to 100 hp., are used to drive the several types of conveyors. The sizes of the drive motors depend upon the size, type, and function of the conveyor used.

Chain-bucket and belt-bucket elevators are employed in some mine tipples, but their use is limited because they are prone to stall when overloaded and are subject to breakdowns in freezing weather.

Tipples are designed to produce 2,000 to 3,000 tons of prepared coal per shift. Some tipples are operated 7-1/4 and others 8 hours per shift. When the demand for lignite is large enough, some mines and tipples are operated more than one shift a day. During the summer, when demand is small, the tipples may be operated only a few hours 1 or 2 days a week. These sporadic operations are necessary because lignite is seldom stored for long periods; consequently, the customers order for their immediate needs.

Truck-loading facilities are available at most tipples to accomodate local customers and those who are outside the areas served by a railroad. Storage and truck-loading bins near the tipple usually are filled while the railroad cars are positioned for loading. This allows the tipple to operate continuously.

Loading booms or boxcar loaders are used to load domestic-size coal into railroad cars. When open-top cars are being filled, the loading booms can be raised or lowered, so that the lignite is dropped only a short distance, reducing excessive breakage.

Generated on 2024-09-21 17:43 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Boxcar loaders are swivel-hinged conveyors designed so that they can be snaked into the boxcars where their discharge ends are maneuvered manually. Most domestic-size coal is loaded into boxcars because the distributors generally do not have facilities for unloading hopper cars.

Most tipples are constructed on relatively level ground. Consequently, the railroad grades in the immediate vicinity of the tipples often are so gentle that the cars cannot move by gravity. Single-drum hoists, locally called "crabs," are used to spot the cars under the tipple and haul them to positions whence they can roll to the gathering yard by gravity.

Dedusting and Freezeproofing

Lignite for domestic use is sprayed with oil to allay dust. Oil is also applied to industrial lignite in the winter as a partly successful means of reducing agglomeration by freezing during shipment to the consumer. Spray oils used at individual mines may differ slightly, but the one commonly used has a viscosity of 750 seconds S. U. at 100° F. Approximately 1 gallon per ton is applied to domestic sizes and 3 to 5 quarts per ton to industrial screenings.

Oil is applied through spray nozzles installed in an enclosed chute as the lignite falls into the car or loaders. It is heated to 100° F. or above (to insure uniform coverage of particles and ease of handling) and distributed in a system operated at pressures of 125 to 160 pounds per square inch. Homemade and manufactured systems are employed to heat the spray oils. One system encloses or traces the oil line with a steam line. A commercial method (Viking Machine Sales Corp.) circulates heated oil in a tracing system. The heating oil is often No. 10 SAE or other light lubricating oil mixed with an equal part of kerosine.

Oil-storage tanks, if aboveground also require heating systems to insure flow in the winter. Coal-fired steam boilers are commonly used to supply the heat for these systems. Costs of oil-spray treatment are not accurately known but have been estimated at 10 to 20 cents per ton.

The study of factors that influence agglomeration of lignite, freezing, and development of optimum or improved treating methods is a current project at the Lignite Experiment Station of the Federal Bureau of Mines at Grand Forks, N. Dak.

Storage

The storage practices of consumers considerably influence mine operation. Being a low-rank, high-moisture fuel, lignite has storage characteristics that discourage consumers from stockpiling it during slack seasons. Production therefore is scheduled according to demand, which is maximum when the weather is most unfavorable.

When exposed to air lignite loses moisture rapidly. The resultant shrinking and spalling of the surface transform the tough, fibrous lumps to small, brittle particles. Domestic sizes, which involve size control, seldom are stored for any period and never throughout the summer.

Generated on 2024-09-21 17:46 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Improperly stockpiled, industrial sizes ignite readily by spontaneous combustion. Carefully placed and compacted emergency stockpiles for 15 to 30 days of operation are maintained by industrial consumers. Where constructed in 1-foot layers and individually compacted to a bulk density of 60 to 65 lb. per cu. ft., large stockpiles give no difficulty from spontaneous heating. Side slopes of piles are maintained at an angle of approximately 17° or less from the horizontal. An example of stable, long-term storage of lignite is provided at Garrison Dam, Riverdale, N. Dak., where more than 2 million tons of lignite (excavated during construction of the dam) has been successfully stockpiled for several years.10/

Overall Production Rates

Production rates per man-day generally fluctuate according to consumer demand and the number of days worked each month. The tons produced per man-day range from about 20 to 75. The higher rate usually is achieved when the mine is operated 25 or 26 days a month. Steady mine operations provide conditions that affect mine production favorably. The machines are maintained better and perform more efficiently. Figure 15 shows graphs of the average daily production in relation to the number of operating days per month for the reported period.

Auxiliary Operations

Mine machine shops are well equipped to repair most mining equipment. Minor structures and parts for equipment can be fabricated. Electrical and mechanical repair work that cannot be done at the mine is sent to the large electrical- and machine-repair shops at Minneapolis, Minn.

Machine shops are constructed of wood or steel. When constructed of steel, the buildings are insulated.

The shop equipment at each mine may differ in detail but generally includes the following:

Type of Equipment

Lathes (12-, 24-, 36-inch)
Drill press
Planer
Saw (power)
Shaper
Press (150-ton, 300-ton, 400-ton)
Compressor (110-lb. pressure)
Hoist (mobile)
Welding machine (electric)
Grinders (table)
Steam pressure cleaner
Electric drills (hand held)
Trip hammer
Acetylene cutting torch
Table saw (wood cutter)
Forge and anvil
Bender (pipe)
Grinder (portable)
Assorted hand tools

10/ Allen, R. R., and Parry, V. F., Storage of Low-Rank Coals: Bureau of Mines Rept. of Investigations 5034, 1954, 31 pp.

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

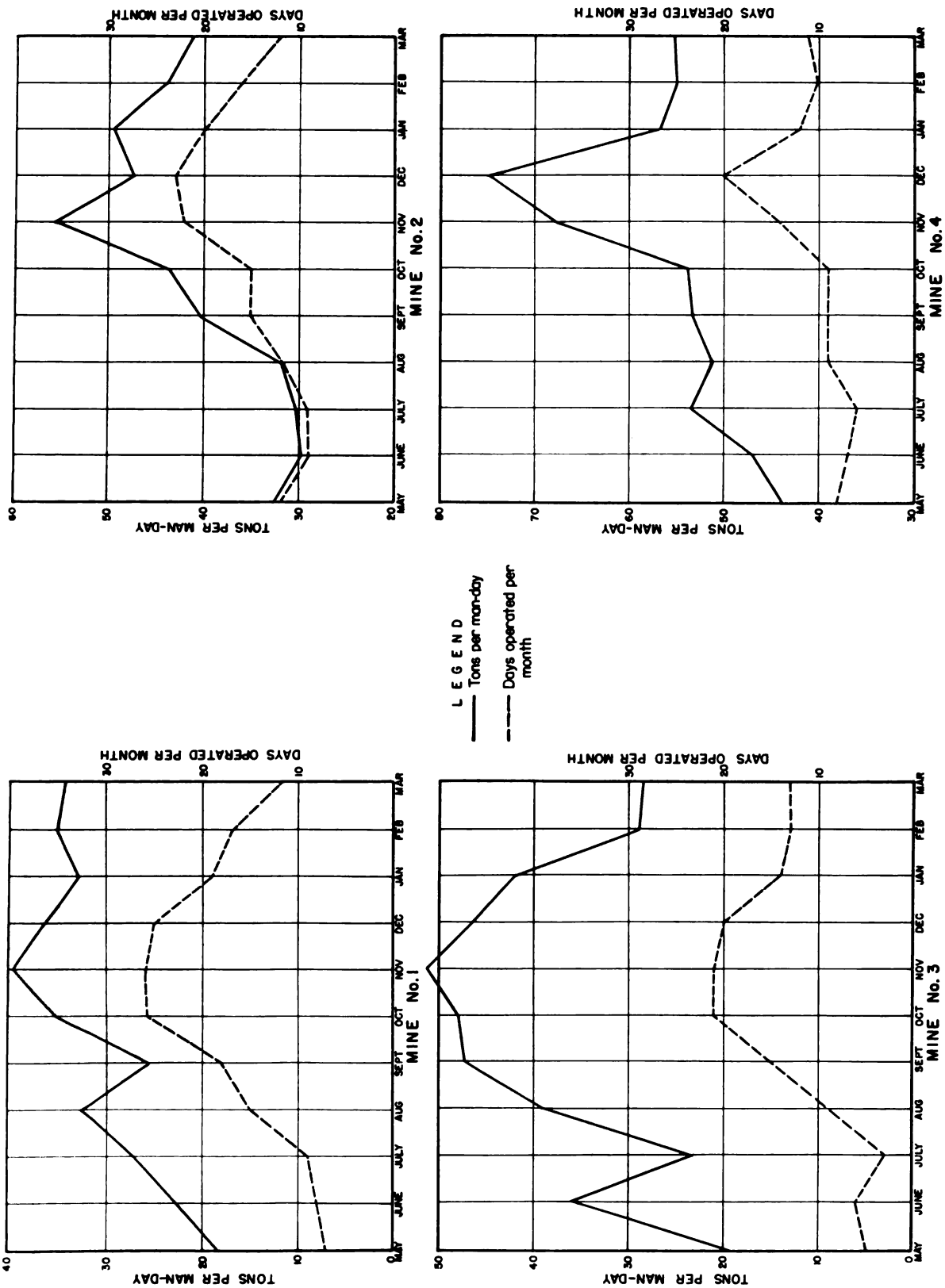

FIGURE 15. - Curves Showing Relationship Between Number of Days Mines Are Operated Per Month and Tons of Lignite Produced Per Man-Day for the Month.

Generated on 2024-09-21 17:42 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Preventive maintenance of all equipment is practiced generally throughout the district. One innovation that has reduced machine "down time" and maintenance costs considerably is to have on hand extra gear and shaft assemblies that can be installed readily whenever a similar assembly fails to function. The faulty assembly is removed from the machine and repaired in the shop, where the separate units can be inspected properly. This prevents using defective parts along with new or sound parts. When on-the-job repairs were made, use of defective parts caused excessive wear and damage. The machines frequently were inactive, and in an emergency repairs were sometimes makeshift resulting in additional down time.

Possibly the equipment most difficult to repair is the dragline bucket. The clay immediately above the coal is usually abrasive, and a dragline bucket ordinarily must be repaired about every 6 weeks. One to three spare buckets are needed at each mine to insure continuous operation of the dragline. An average of 10 man-shifts is required to repair a bucket. Hard-surfacing metal and manganese-steel wedge bars are used for these repairs. From 15 to 30 pounds of this material, costing $0.54 to $1.25 per pound, is used for each repair.

Dragline-bucket teeth usually must be replaced after being used about 24 hours. Tests are continually being made, using different types and makes of bucket teeth. Molybdenum-alloy-steel teeth were being tested when the Knife River mine at Beulah was visited.

Transport trucks are garaged in weatherproof buildings. Service pits, tire-mounting equipment, air compressors, and greasing equipment are provided. Safety chains or specially designed safety devices are used when tires are inflated.

Explosives magazines are constructed by digging into an isolated hillside. The excavation is lined with timber, and an insulated bullet- and vandal-proof door is installed at the entrance. Separate magazines are provided for explosives and detonating caps.

Power Sources and Rates

Public utilities and rural electric cooperative associations provide 41,600-volt, 3-phase, 60-cycle electric power for the mines. It is stepped down to 4,160 volts at mine substations and transmitted to the mine pits over company lines.

Circuit breakers installed at the transformer stations in the 4,160-volt line are actuated either by overload or by ground-conductor current. These devices usually are set to reclose about 5 or 10 seconds after tripping the first time. If the trouble has not cleared in that period, the breaker again cuts out. The power remains off 10 or 20 seconds or about twice the time allowed for the first interruption, and the circuit breaker again closes automatically. If the breaker is tripped a third time, it will remain open until it is reset manually. Three conductor, rubber-insulated trailing cables transmit power to the operating equipment and are connected to the transmission lines through semiportable or skid-mounted enclosed junction boxes containing low-amperage, ground, trip relays. (See fig. 16.) These circuit breakers are

Generated on 2024-09-21 17:45 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:44 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

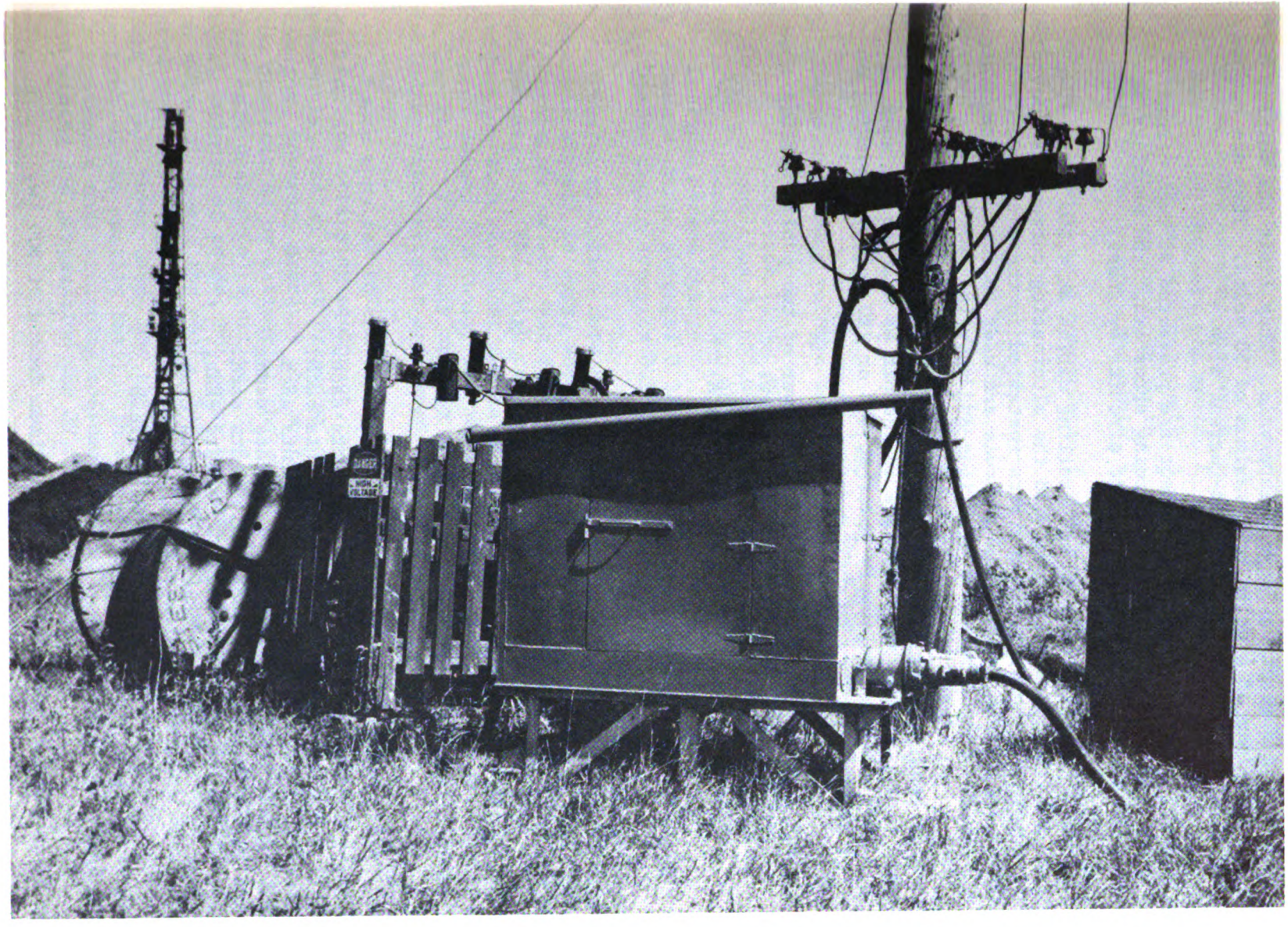

FIGURE 16. - Portable Transformer Station and Safety Junction Box Used to Connect Trailing Cable to 4,160-Volt Powerline.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

also set to trip and reset on 3-cycle intervals. They limit the voltage to ground from a minimum of 4 volts to a maximum of 50 volts. They are opened by overloads, short circuits, or ground-current flow.

All powerlines and electric equipment are protected at each circuit breaker and transformer station by lightning arrestors. The machines are doubly protected from overloads and short circuits by fuses.

Power is transmitted through the trailing cables at 4,160 volts a.-c. The voltage usually is stepped down, and the alternating current is converted to direct current by motor-generator sets installed in the equipment cabs. Ward Leonard, Magnetron, or similar controls are used to start and regulate the d.-c. motors that operate the draglines and shovels.

Portable banks of transformers, ranging in capacity from 5 to 25 kv.-a., usually are placed on the highwall side of the pit as near to the sump as possible. They are used to supply power at 440 or 220 volts, depending on the type of pump motor.

Industrial rate schedules for electric power of two public utility companies in different sections of the State follow:

Rate Schedule A

Demand charge for secondary voltage service:

First 10 kw., $3.25 per kw. per month.
Next 40 kw., 2.50 per kw. per month.
Next 50 kw., 2.00 per kw. per month.
Excess kw., 1.80 per kw. per month.

Demand charge for primary voltage service:

As above, less $0.20 per kw. per month.

Energy charge:

First 1,000 kw.-hr. per month, 4.0 cents each.
Next 3,000 kw.-hr. per month, 3.0 cents each.
Next 6,000 kw.-hr. per month, 1.8 cents each.
Next 10,000 kw.-hr. per month, 1.6 cents each.
Next 30,000 kw.-hr. per month, 1.4 cents each.
Next 50,000 kw.-hr. per month, 1.3 cents each.
Excess kw.-hr. per month, 1.2 cents each.

Rate Schedule B

Demand charge:

60 cents per kw. per month, with a minimum demand of 300 kw.

Generated on 2024-09-21 17:44 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Energy charge:

First 5,000 kw.-hr. per month, 5 cents each.
Next 5,000 kw.-hr. per month, 4 cents each.
Next 5,000 kw.-hr. per month, 3 cents each.
Next 35,000 kw.-hr. per month, 2 cents each.
Over 50,000 kw.-hr. per month, 1.5 cents each.

The following is a comparison of power charges using the preceding rate schedules:

	Rate schedule A[3]		Rate schedule B[4]	
Usage[1] per month	Total charges[2]	Cost per kw.-hr.,[2] cents	Total charges[2]	Cost per kw.-hr.,[2] cents
1	$4,720.50	1.57	$5,350.00	1.78
2	9,120.50	1.52	10,150.00	1.69
3	13,520.50	1.50	14,950.00	1.66

1/ Based on primary voltage service, 83-percent-load factor, and power factor above 0.85:
Condition 1, 300,000 kw.-hr. energy, 500 kw. demand.
Condition 2, 600,000 kw.-hr. energy, 1,000 kw. demand.
Condition 3, 900,000 kw.-hr. energy, 1,500 kw. demand.
2/ Includes demand charge.
3/ Demand charge averages 0.28 cent per kw.-hr.
4/ Demand charge averages 0.1 cent per kw.-hr.

Power-consumption data at 1 mine indicate that the average monthly unit rate was highest in July, when it was 2.61 cents per kw.-hr. The lowest rate, 1.76 cents per kw.-hr. was in September, when power consumption was highest, 298,200 kw.-hr. This high consumption of power reflects the increase in coal production with resultant increased load factor that was necessary to supply the peak demand for fuel. The maximum fuel-production rate occurs annually in the fall. The yearly average rate was 2.01 cents per kw.-hr. at this mine, including extra service and demand charges.

Power supplied to the individual machines or to separate operations, such as tipples, stripping equipment, and mining equipment, is not measured independently, and an exact breakdown of power cost is not available. One mining company, however, prorates the monthly power cost against stripping, mining, and preparation by estimating the power consumed according to the number of days each operation is active. Mining and preparation are assumed to consume equal amounts of power, but power consumed by stripping is variable, depending on seasonal demand for coal. For example; in summer, when the mine is operated only a few days a month, the stripping machinery consumes about 70 percent of all power used, and the tipple and loading machinery each consume 15 percent of the monthly total. In winter, when demand for coal increases, it is estimated that stripping consumes about 35 percent of total power used, and mining and preparation use 32.5 percent each.

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Fire Prevention

Periodic inspections of equipment, buildings, and preparation plants are made to eliminate fire hazards. Fire extinguishers are placed in all stripping, loading, and transporting equipment and at easily accessible places in all buildings. Fire hose and water hydrants for fire fighting adjoin most large establishments. Occasionally, there are fire drills to train personnel who work in or near the shops and tipples.

Safety and First-Aid Organization and Training

Bureau of Mines first-aid and safety courses have been made available to most miners within the preceding 3 years. Some companies use National Safety Council literature and posters to encourage safe working habits. Prompt action on the part of management to eliminate hazards and employee cooperation in following safety rules contribute to a good safety program.

Supervision and Management

Truax-Traer Coal Co. operates 4 mines, of which 2 are 200 miles apart. A general manager of mines, stationed at Minot, supervises the mine superintendents. The mine superintendents are assisted by pit foremen and a tipple foreman. Usually each mine has a chief mechanic and a chief electrician responsible for the men working under them subordinate to the mine superintendent. A mechanical engineer and an electrical engineer, in charge of their respective departments at the mines, are stationed at headquarters in Minot. The engineers are supervised by the general manager.

A mining engineer under the general manager's direction works out of Minot and visits the various mines as his services are required.

The Knife River Coal Mining Co. has about the same plan of organization, except that its headquarters is in Bismarck, N. Dak.

Baukol-Noonan, Inc., operates only one mine; consequently, it does not need a general manager or traveling engineers. Private consultants do the mine surveying and engineering.

Wage and Contract Systems

Miners employed by Truax-Traer Coal Co. work under a contract agreed to by the United Mine Workers of America and the company. The Progressive Mine Workers of America have a contract with the Knife River Coal Mining Co. Employees of Baukol-Noonan, Inc., are not unionized.

The following wage rates were paid in 1956 by Truax-Traer Coal Co. and Knife River Coal Mining Co. working under union contracts:

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Classification	Wage scale (per hour)
Employed at mine	
Shovel and dragline operator	$2.994
Shovel and dragline oiler	2.663
Euclid truckdriver	2.514
Patrol operator	2.514
Bulldozer operator	2.514
Shot firer	2.514
Pumpman	2.464
Employed at tipple	
Foreman	2.764
Operator	2.564
Oiler	2.564
Loaders	2.514
Car dropper	2.364
Crab operator	2.514
Employed on railroad (Truax-Traer Coal Co.)	
Engineer	2.664
Brakeman	2.664
Fireman	2.564
Track boss	2.764
Track helper	2.364
Car cleaner	2.514-2.364
Employed at machine shop	
Chief mechanic	2.994
Welder	2.663
Electrician	2.663
Employed at carpenter shop	
Carpenter	2.663
Camp-maintenance worker	2.364
Watchman	1.888

The following wage rates are paid nonunion employees at the Baukol-Noonan mine:

Classification	Wage scale (per hour)
Shovel operator	$3.03
Oiler	2.58
Bulldozer operator	2.58
Tipple foreman	2.58
Mechanic, welder, shopman	2.78
Truckdriver, tractor operator, tippleman	2.48
Common laborer (base pay)	2.43

Generated on 2024-09-21 17:43 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Labor relations under union contracts follow prescribed rules, which are established generally throughout the lignite industry. Nonunion mines, although not bound by formal contracts, more or less follow the same plan. For example, if an employee has a grievance, he is encouraged to talk the matter over with his immediate supervisor. If the problem cannot be resolved at this level, it is presented to the next higher authority, and so on, until a solution or agreement is reached. If the problem concerns a group of employees, a spokesman or committee is appointed to present the grievance. This action must be carried through the chain of management in the same manner as an individual complaint.

COST OF MINING LIGNITE IN NORTH DAKOTA

Table 2 summarizes cost data for 4 of the 6 mines studied. Costs do not include the contribution of 20 cents per to the United Mine Workers' Welfare Fund. Table 2 also shows the percentage of direct mining costs and total mining costs attributed to individual items. Direct mining costs are distributed under labor, supervision, and power and supplies. These cost items are shown as percentages of the total direct mining costs in table 3.

The weighted average cost of producing lignite at the 4 mines in 1955-56 totaled $1.32 per ton (exclusive of contributions to the United Mine Workers' Welfare Fund). Production per man-shift ranged from 31 to 56 tons, averaging about 41 tons.

INDIVIDUAL MINE OPERATIONS

Six of the seven major producing lignite mines were visited, and operating conditions and procedures were observed. Three companies operate these mines as follows: Baukol-Noonan, Inc., Noonan mine; Knife River Coal Mining Co., Beulah mine; and Truax-Traer Coal Co., Custer, Dakota Star, Kincaid, and Velva mines.

Baukol-Noonan, Inc.

Noonan Mine

The Noonan lignite strip mine is about 1 mile east of Noonan, Divide County, N. Dak., a station on the Great Northern Railway. Operation of the mine began in 1930 under the management of Baukol-Noonan Lignite Co., a subsidiary of Noonan Holding Co., which had been formed by a group of local men. Baukol-Noonan, Inc., acquired control of the property in 1950 by purchasing the stock of the predecessor concerns and now operates the mine.

The annual production of coal from the Baukol-Noonan mine for the period 1952-56 is as follows:

Year	Production, short tons
1952	311,561
1953	259,430
1954	236,162
1955	293,030
1956	286,874

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:45 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

TABLE 2. - Summary, costs of producing lignite in North Dakota, 1955-56

	Data for 4 mines				Weighted average	Percentage of mining cost	Percentage of total cost
Direct mining costs, cents per ton:							
Stripping	36.76	26.37	35.47	13.72	28.27	31	21
Loading	20.83	13.24	15.91	12.05	15.82	17	12
Hauling	14.00	11.17	10.90	12.83	12.41	13	9
Preparation	17.68	15.78	18.57	17.89	17.20	19	13
Total	89.27	66.56	80.85	56.49	73.70	80	55
Special direct mining costs, cents per ton:							
Railroad	9.43	10.68	.41	-	6.72	7	5
Camp maintenance	4.17	2.33	4.60	4.61	3.70	4	3
Total	13.60	13.01	5.01	4.61	10.42	11	8
Indirect mining costs, cents per ton:							
Supervision and engineering	3.02	4.24	7.78	4.94	4.43	5	3
Warehouse facilities	1.64	1.14	2.97	1.86	1.69	2	2
Vacation pay	1.85	1.43	1.65	1.10	1.53	2	1
Total	6.51	6.81	12.40	7.90	7.65	9	6
Total mining, direct, special direct, and indirect costs, cents per ton	109.38	86.38	98.26	69.00	91.77	100	69
Overhead costs, cents per ton:							
Main-office salaries	1.07	.81	2.13	1.41	1.19		1
General supervision	4.21	4.11	3.54	3.78	4.00		3
Taxes	3.36	3.23	3.63	3.79	3.44		3
Insurance	2.24	1.99	2.58	1.92	2.13		2
Depreciation	10.49	16.30	24.28	20.08	16.20		12
Depletion	2.19	1.13	.00	2.53	1.63		1
Miscellaneous and royalties	4.53	12.35	18.70	18.82	11.95		9
Total	28.09	39.92	54.86	52.33	40.54		31
Total mining and overhead costs, cents per ton	137.47	126.30	153.12	121.33	132.31		100
Average tons per man-day	31.34	41.32	39.86	56.14	40.98		

1/ Weighted according to the tonnage produced from each mine.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 3. - Distribution of direct mining costs, percent[1/]

	Labor	Supervision	Supplies, including power	Total
Stripping	52	6	42	100
Loading	58	3	39	100
Hauling	57	4	39	100
Preparation	60	9	31	100
Average	56	6	38	100

1/ Distribution prepared from cost data of 4 mines.

Forty-one men, including 2 supervisors, are employed at the Baukol-Noonan mine. Distribution of the employees among the various job classifications follows:

Classification	Number employed
Supervisor	2
Dragline and shovel operator	6
Oiler	6
Bulldozer operator	1
Euclid truckdriver	5
Tractor operator	1
Patrol operator	1
Electrician and mechanic	4
Tipple foreman	1
Tippleman, car dropper, common laborer	14

About 2,000 tons of coal is produced from the mine per 8-hour shift - equal to the tipple capacity of 250 tons per hour.

Contour strip mining has always been practiced at the Baukol-Noonan pit. Before 1945 a lignite-burning steam shovel was used to remove overburden. Since then an electric-powered dragline has been used. The track-haulage system from the pit to the preparation plant was replaced in 1949 by truck haulage.

Overburden consists chiefly of blue-gray to brownish-yellow argillaceous material containing sand lenses overlain by glacial till.

Two coal beds occur in the Fort Union formation near the Baukol-Noonan mine. The upper bed (10 to 40 feet below the surface) is lenticular and ranges in thickness from a few inches to as much as 3 feet. About 50 percent of this bed is weathered to a material locally called slack (more recently called leonardite). A small percentage of the slack has been mined and sold for mixing with drilling mud. Where it is 2 or more feet thick and not weathered, coal in the upper bed is mined for marketing. About 30 feet of material, predominantly blue-gray clay with sandstone lenses in the upper part, separates the lower and upper coal beds. Thickness of the lower coal bed averages 7 feet.

At times, about 2 feet above the bottom, a clay parting occurs that ranges in thickness from a few inches to as much as 1 foot. Below the lower lignite

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

bed is a bed of light-gray clay 6 to 10 feet thick. This clay is exploited as lightweight aggregate after being bloated in a rotary kiln.

About 10 prospect holes are drilled each year in advance of the mine workings. This program generally blocks out reserves that about equal the annual production. Drilling is done with churn drills, and coal samples are obtained by drive piping. Local well-drilling contractors are hired to drill at a rate of $1.75 per foot of hole. Figure 17 is a map of the mine and prospect-drill pattern.

Overburden is stripped with a Bucyrus-Erie, Monighan Model 9-W, walking dragline equipped with a 160-foot boom and a 10-cubic-yard bucket. Supported by a flat tub of considerable area, the walking dragline can operate safely on soft ground near coulees and on unconsolidated spoil piles. It may also be moved with ease on the paddle feet, which are of comparable area.

When both beds are recovered, the ratio of overburden to coal for the upper bed is 10 and to the lower bed 3. The stripping ratio in recovering only the lower bed is about 8. The dragline is operated initially from the top of the overburden on the highwall side of the pit. (See fig. 18.) Material above the top lignite bed is excavated toward the machine in the direction of the pit advance and parallel to the mined-out strip pit. The width of the excavation is about 110 feet. Spoil is cast into the area from which lignite has been mined in the adjacent strip. If the upper lignite bed is of good quality and recoverable, the first cut is made to the top of the coal. If not, the coal is spoiled with the waste rock. The dragline is advanced several hundred feet on this bench or as much as a thousand feet. It is then moved down a ramp, cut in the overburden by a bulldozer, and graded by a patrol to the top of the bench developed by the first phase of stripping.

In the second position a key cut or slot is made to establish alinement of the highwall parallel to the mined-out strip and to provide a starting point for the final operation. The key cut is dug about 10 feet wide at the bottom and 25 feet or more wide at the top, depending on the depth of overburden. Spoil from this second or key cut is cast behind the first pile toward the spoil from the previously mined strip. The spoil from these two cuts is then leveled by bulldozer and patrol grader for the third and last position of the dragline in the stripping operation. Smooth and relatively firm access ramps must be provided for the dragline to avoid upsetting it.

The third and last cut is made by dropping the bucket in the key cut, dragging it across the width of remaining overburden, and casting the spoil behind the dragline and on the leveled spoil piles. Close supervision and coordination are required to keep movements of the dragline to a minimum.

Most highwalls are dug on a 1 to 3 slope. To insure stability, where the overburden consists chiefly of loosely consolidated sands, gravels, and boulders, the slope must be maintained at 1 to 2 or less. The angle of repose of the spoil averages about 38°. The volume of material stripped from the lignite is estimated by the operators to increase about 20 percent when spoiled.

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

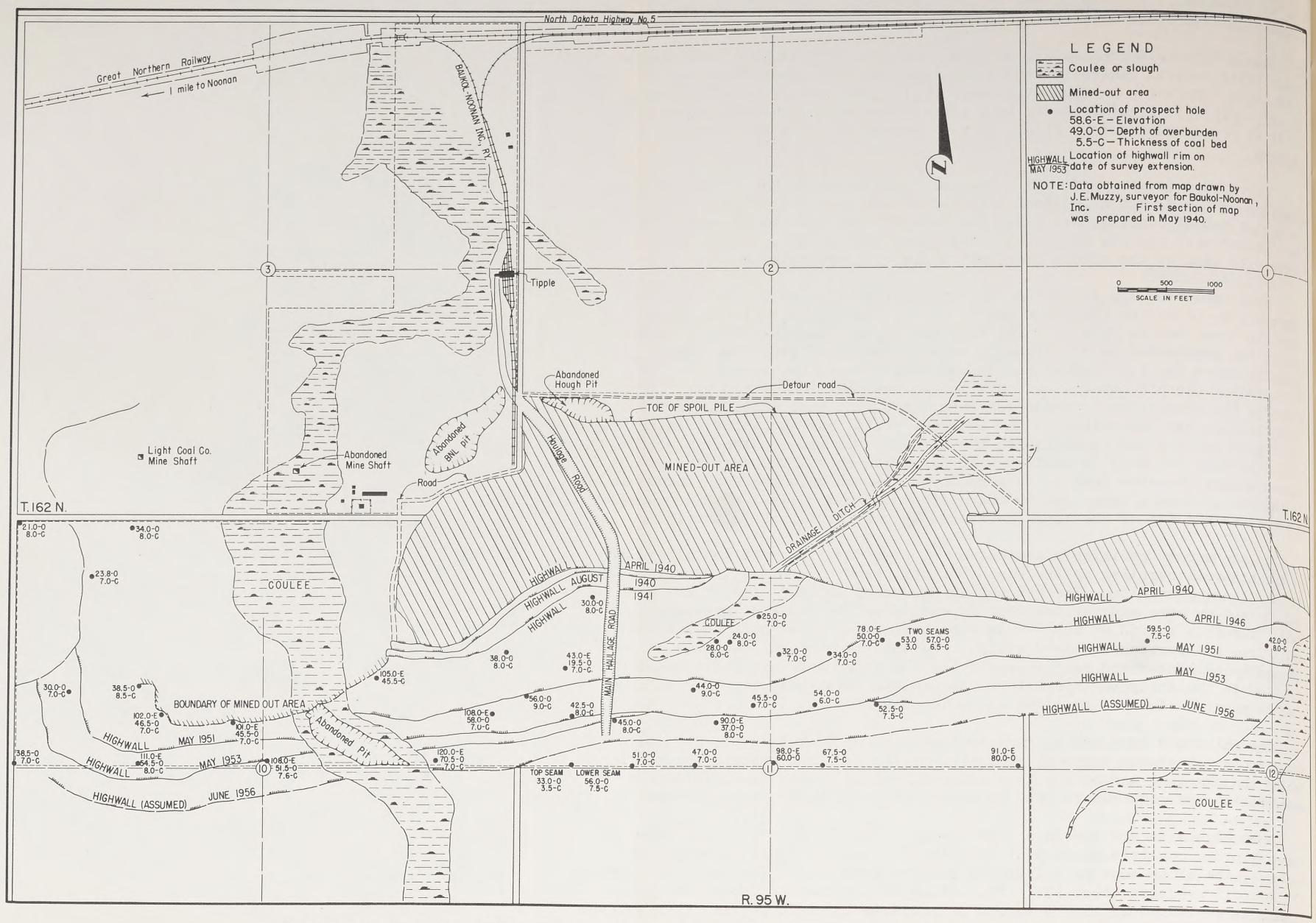

FIGURE 17. - Map of Baukol-Noonan, Inc., Open-Pit Lignite Mine Near Noonan, Divide County, N. Dak.

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

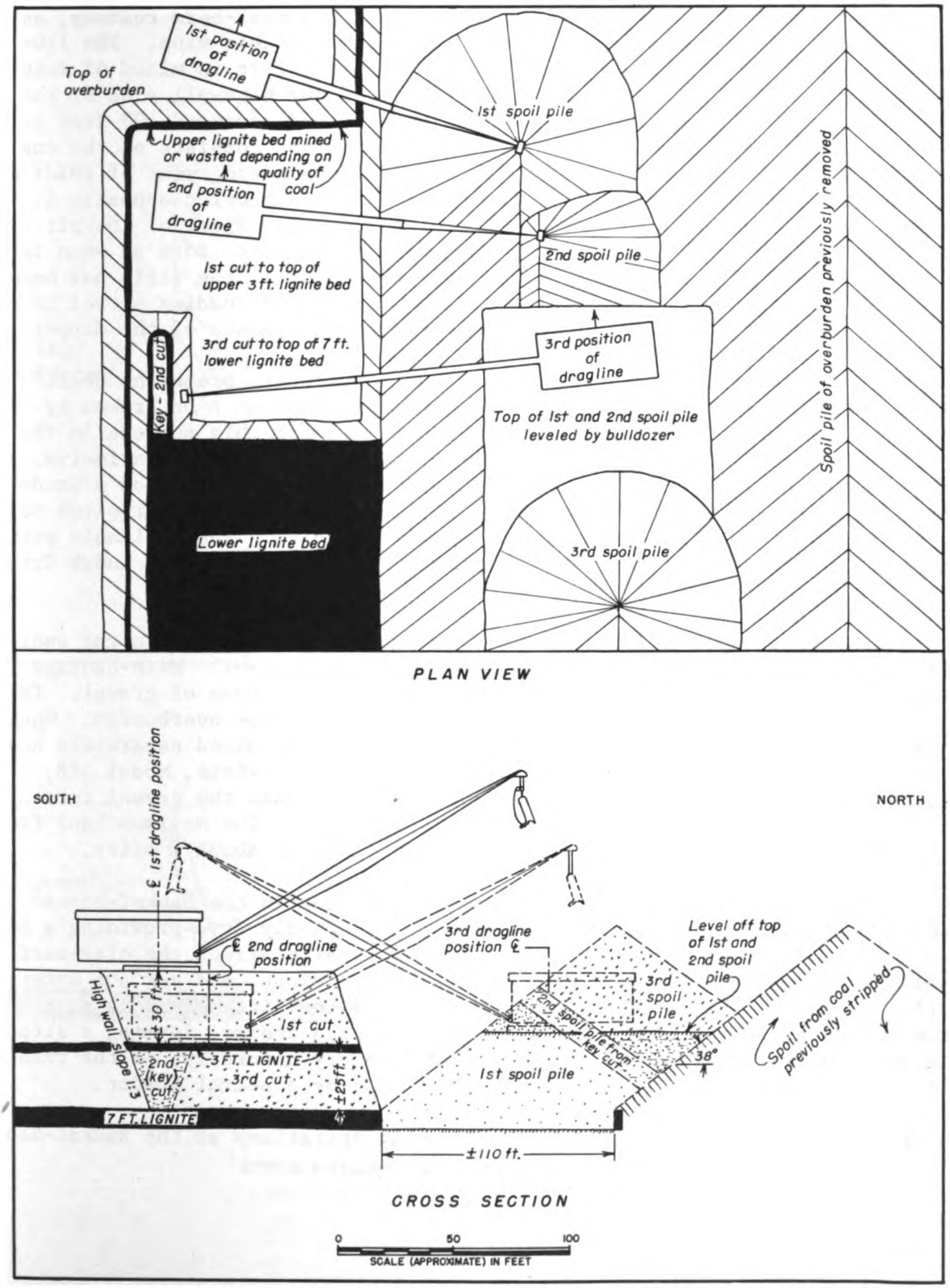

FIGURE 18. - Baukol-Noonan, Inc., Method of Strip Mining Two Lignite Coal Beds by Walking Dragline.

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

All stripped coal can be loaded without using a coal-berm roadway, as ground water is not present in appreciable amounts at this mine. The 110-foot-wide coal strip is mined in 3 lifts. The first lift is mined 45 feet wide and advanced about 400 feet along the toe of the highwall side of the pit. The second lift is mined about 32 feet wide and advanced 400 feet or even with the face of the first. The third lift mined consists of the coal next to the spoil pile. In some areas, where a loop arrangement of roads and ramps is not feasible, the third lift is mined in a direction opposite to the other lifts to provide minimum truck travel on the clay floor of the pit. (See fig. 19.) When the three lifts have been advanced to form an even face across the width of the pit, the cycle is repeated until the strip has been completely mined out. A 3-cubic-yard, electric-powered loading shovel is used that can fill the 20-ton-capacity trucks with 8 passes of the dipper.

Normally, drilling and blasting are not required to break the coal. In winter small areas in the coal occasionally freeze and must be broken by blasting. Only five cases of Stripkolex were used for this purpose in the winter of 1956. Stripkolex is a low-velocity, water-resistant explosive, heavy enough to sink readily. Blast holes are drilled by means of a Cardox Corp., portable, gasoline-engine-driven drill, fitted with a flat-pitch coal auger 2.5 inches in diameter and tungsten carbide bits. The drillhole pattern and blasting procedure are similar to those previously described under Drilling and Blasting Practice.

Access to the pit is provided over ramps constructed through the spoil pile as mining is advanced away from the preparation plant. Main-haulage roads are built with a base course of clay and a top course of gravel. The gravel is obtained from deposits in the upper part of the overburden. When a large deposit is encountered during stripping, it is mined separately and stockpiled beyond and near the pit highwall. A Bucyrus-Erie, Model 32B, diesel-powered shovel with a 1.5-cubic-yard dipper loads the gravel into Euclid trucks which transport it to the place of use. The maximum haul from the mine pit to the coal-preparation plant and back is about 7 miles.

Only a small amount of ground water accumulates in the Baukol-Noonan pit. Underclay exposed by mining the coal remains relatively dry, providing a good road surface. Summer showers and winter snow squalls affect the clay-surfaced roads only slightly. The clay is relatively impervious, and surface water rapidly drains to the sumps and is pumped out of the pit. Moisture penetrates a few inches below the clay surface during extended storms, forming a slippery roadway. The road surface is either allowed to dry naturally, or the thin skin of moist, slick clay is scraped to the side by a patrol grader.

The following equipment is used in mining operations at the Baukol-Noonan mine:

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

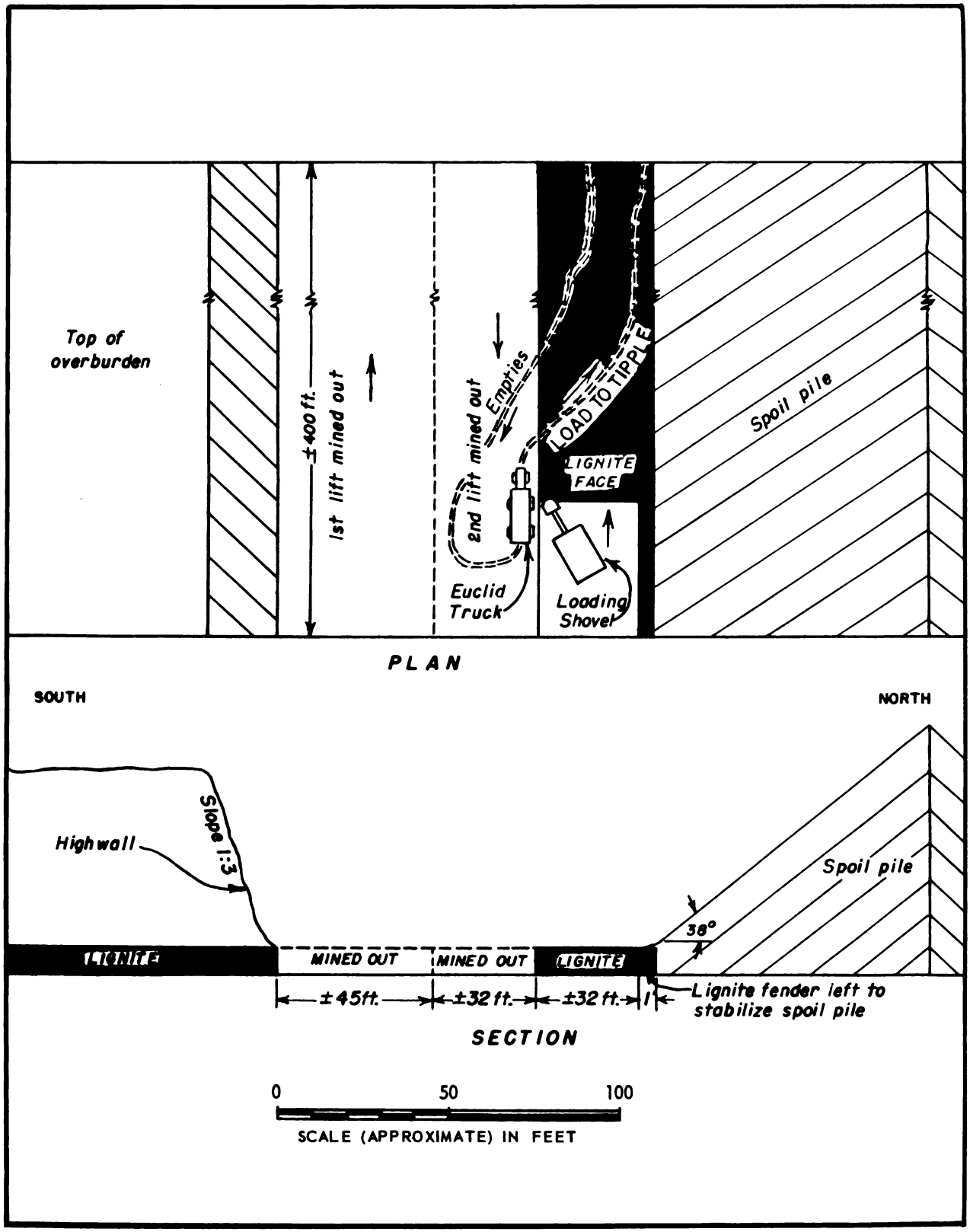

FIGURE 19. - Baukol-Noonan, Inc., Method of Mining Lignite Coal.

Generated on 2024-09-21 17:48 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Stripping Equipment

Quantity	Description
1	Walking dragline, 160-foot boom, 10-cubic-yard bucket, Model 9W-Monighan, Bucyrus-Erie Co.

Loading Equipment

1	Electric loading shovel, 34-foot boom, 3-cubic-yard dipper, Model 50-B, Bucyrus-Erie Co.
1	Diesel loading shovel, 1.5-cubic-yard dipper, Model 32-B, Bucyrus-Erie Co.

Auxiliary Equipment

2	Bulldozers, Model D-7, Caterpillar Tractor Co.
1	Front-end loader, Payloader, F. G. Hough Co.
1	Patrol grader, Model 112, Caterpillar Tractor Co.
1	Tractor, Model HD-5, Caterpillar Tractor Co.
1	Tractor scraper, Model W-6, International Harvester Co.
1	Portable drill, gasoline motor, Cardox Corp.

Transportation Equipment

5	Trucks, 20-ton-capacity, bottom-dump, Model 27-FTD-83W, Euclid Div. General Motors Corp.
1	Truck, 2-ton-capacity.
1	Pickup truck, 0.5-ton-capacity
1	Pickup truck, 0.75-ton-capacity.

Pumping Equipment

1	Pump, 2-stage-centrifugal, 1.5-inch-discharge, 15-hp., electric motor, Fairbanks-Morse & Co.
2	Pumps, 2-stage-impeller, 2-inch-discharge, 20-hp., Electric motor, McNally-Pittsburgh Mfg. Co.
2	Pumps, 1-stage-impeller, 2-inch-discharge, 20-hp., electric motor, McNally-Pittsburgh Mfg. Co.
1	Pump, centrifugal, 1.5-inch-discharge, 10-hp., gasoline motor, Gorman Rupp Co.
1	Pump, centrifugal, 1.5-inch-discharge, 10-hp., electric motor, Gorman Rupp Co.
2	Pumps, dual-prime-centrifugal, 1.5-inch-discharge, 7.5-hp., gasoline motor, Construction Machinery Co.

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

When the tipple was built in 1930, it was designed to supply a market for plus-2-inch-sizes. The original tipple has been altered from time to time, as the market for sized coal has changed. Now, coal prepared at the Baukol-Noonan tipple is broadly classified by the operator as domestic (plus-2-inch size) and industrial (minus-2-inch size). During the period covered by this report, 30.5 percent of the coal was prepared for domestic and 69.5 percent for industrial use.

The domestic coal is divided into two classes: (1) Stove and furnace and (2) domestic stoker. These sizes constitute 15.7 and 14.8 percent, respectively, of the total preparation-plant production. Table 4 lists installed equipment and horsepower rating of individual driving motors in the tipple. Figure 20 gives a schematic flow plan of the tipple.

TABLE 4. - Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Baukol-Noonan mine

Equipment	Number	Rated hp.
Primary crushers	1	75
Secondary crushers	1	50
Screens	1	35
Do.	1	7.5
Do.	1	5
Conveyors:		
Belts	1	15
Do.	1	10
Apron or pan	1	50
Do.	1	25
Do.	1	10
Chain-flight	2	7.5
Do.	1	10
Do.	1	15
Do.	1	5
Bucket elevators	1	15
Do.	1	7.5
Boxcar loaders and auxiliary equipment	1	7.5
Do.	2	5
Railroad-car hauls	1	25
Do.	1	20
Do.	4	10
Total	26	452.5

Knife River Coal Mining Co.

Beulah Mine

Knife River Coal Mining Co. is a subsidiary of the Montana-Dakota Utilities Co. Its Beulah mine is about 5 miles north of Beulah, Mercer County, N. Dak., and just south of State Highway 7. The property was first exploited as an underground mine opened in the Beulah-Zap coal bed in 1918. Contour strip mining was begun in 1950, and by 1952 all coal was being mined from open pits.

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

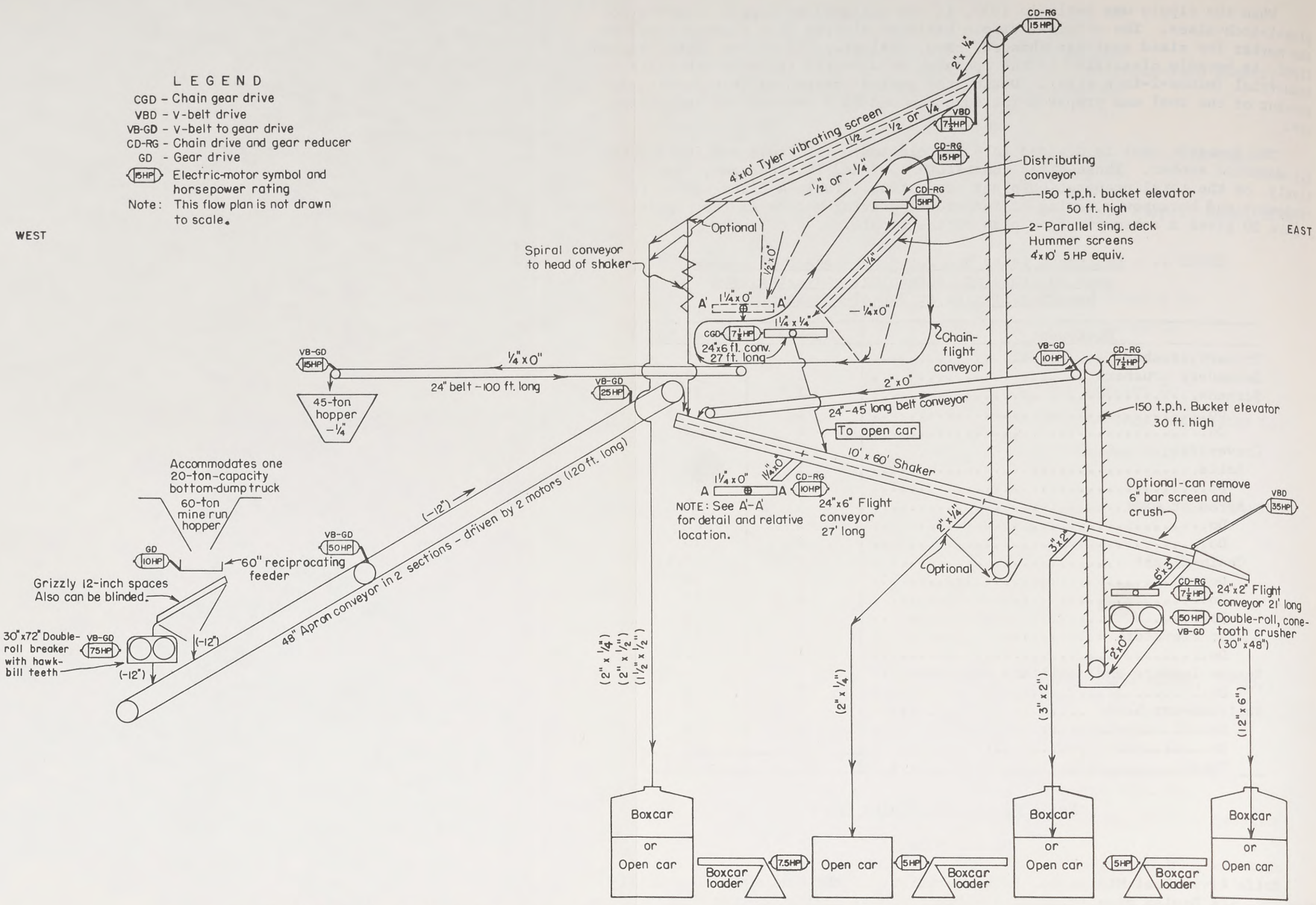

FIGURE 20. - Flow Plan of Baukol-Noonan, Inc., Lignite Preparation Plant, Noonan, Divide County, N. Dak.

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The annual production of coal from the Beulah mine for 1952-56 follows:

Year	Production, short tons
1952	380,408
1953	311,173
1954	333,832
1955	379,986
1956	366,195

Forty-four men are employed at the Beulah mine, including office and supervisory forces. The number employed and job classifications follow:

Classification	Number employed
Supervisor	3
Office personnel	3
Dragline operator	3
Oiler	3
Loading-shovel operator	1
Oiler	1
Bulldozer operator	1
Truckdriver	5
Mechanic	2
Truck maintenanceman	2
Surface, common laborer	3
Tipple operator, car dropper, oiler, etc.	17

The preparation plant was operated for 228 shifts during the report period; the fiscal year ended June 30, 1956. A total of 366,195 tons of coal was produced during the period, an average of about 1,600 tons per 8-hour shift.

The thickness of overburden ranges from 30 to 65 feet and averages about 45 feet. The thickest overburden occurs at the west end of the property. A blue-gray clay usually occurs immediately above the Beulah-Zap coal bed. In places, erosion has removed the clay bed, and younger glacial deposits now lie unconformably upon the coal. Where the clay is not eroded, underlying coal is of good quality; however, beneath the glacial till the coal usually is weathered at the top and often through its entire thickness. In some places the coal bed has been eroded away entirely. A layer of sandstone concretions occurs about 15 feet below the surface in the west pit. In places the concretions are only a few inches in diameter; in others, they may be several feet in diameter and several hundred feet in length. This hard material is drilled and blasted so that it can be moved easily with the dragline.

The coal bed is 12 to 18 feet thick and dissected by tributary streams of the Knife River. Locally, the bed is in an elongated spur hill that trends southerly. Coal outcrops around the hill, and the two contour strip pits have been developed along the west and east edges of the deposit. Each of these pits is about 0.75 mile long.

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The overburden is stripped with a Bucyrus-Erie Monighan walking dragline (Model 7W), equipped with a 160-foot boom and a 6-cubic-yard bucket. It is removed in a 100-foot-wide strip in 2 steps. First, a key cut, 25 feet wide or more, is dug to the surface of the lignite bed to develop the highwall of the new contour strip pit. The highwall is established at a 1 to 3 slope. The dragline is operated from the undisturbed surface, and the bucket is pulled in the direction toward which the pit is being advanced. From this position a direct pull can be applied to the bucket to dig the comparatively solid overburden without blasting it first. Waste from the key cut is spilled into the mined-out area to form a small pile along the side of the coal to be stripped.

The second step is to remove the 75-foot-wide spur of overburden remaining between the key cut and the mined-out strip.in the same way as the first cut was developed with the dragline operating from the spur of overburden being removed. However, in this operation the waste can be cast over and behind the small spoil pile derived from the key cut. This spoil pile is built up until the slope facing the pit merges with that of the first pile. An advantage to building the spoil pile in two stages is that the initial pile from the key cut can settle before the spoil from the second cut is cast behind and onto it; thus, it stabilizes the whole mass and helps to prevent the spoil from sliding to the stripped lignite surface.

As at all mines, the pits are laid out to take advantage of outside curves. Straight-line pits are acceptable, but the ideal plan includes as many outside curves as the topography will allow so that maximum space for spoil is provided.

The coal is broken for loading by blasting. Drilling is done with a company-made drill, powered by a gasoline-driven motor. A 2-inch-diameter coal auger fitted with "Master" throwaway drill bits is used. Lump Coal C, a permissible explosive, detonated by electric delay blasting caps fired by a blasting machine, is used to break the coal. The square-drill-hole pattern and blasting procedure have been described previously.

The end-dump trucks used at the Beulah mine are loaded and operated while they are on a coal-berm road along the strip being mined. (See fig. 7.) Each pit has 4 access ramps, 1,300 feet apart - 1 at each end and 2 between these end ramps. The ramps at the east pit cut through the highwall side of the pit to shorten the haul, and the ramps at the west pit cut through the spoil pile.

Ramps and main-haulage roads to the preparation plant are surfaced with a mixture of about 1 part raw clay and 3 parts natural-burned clay (scoria), which occurs extensively in the area. The maximum round-trip haul between the mine and the tipple adjacent to the powerplant at the east edge of Beulah is 7.5 miles.

Because the coal bed mined at Beulah is within a narrow spur, which is well drained by natural draws, ground water is not a problem. Surface water is adequately intercepted by dikes and ditches, and the small runoff that flows into the pit is pumped out easily.

Generated on 2024-09-21 17:57 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The following equipment is used at the Beulah mine:

Stripping Equipment

Quantity	Description
1	Walking dragline, 160-foot boom, 6-cubic-yard bucket, Model 7W-Monighan, Bucyrus-Erie Co.

Loading Equipment

1	Loading shovel, 60-foot boom, 3.75-cubic-yard dipper, Model PH-1400, Harnischfeger Corp.

Auxiliary Equipment

1	Front-end scoop loader, Frank S. Hough Co.
1	Bulldozer and scraper, Model TD-24, International Harvester Co.
1	Patrol grader, Model 12, Caterpillar Tractor Co.
1	Mobile compressor, Ingersol-Rand Co.
1	Jackhammer, Ingersol-Rand Co.

Transportation Equipment

6	Trucks, 20-ton-capacity end-dump, 200-hp., Cummings diesel, Mack Truck, Inc.

Pumping Equipment

1	Pump, 3-inch-centrifugal, gasoline-motor, Gorman Rupp Co.
1	Pump, 6- by 6-inch-piston, 3-inch-discharge, electric motor, Gould Co.
1	Pump, 5- by 5-inch-piston, 2-1/2-inch-discharge, electric motor, Gould Co.
1	Pump, centrifugal, 4-inch-discharge, electric motor.
1	Pump, portable-centrifugal, 1-1/2-inch-discharge, gasoline motor, Gorman Rupp Co.

As at the Noonan mine the tipple was originally designed to supply a market largely domestic. Picking tables were provided to remove the bony coal and other impurities peculiar to the Beulah-Zap bed. The original tipple has been altered as necessary to provide for increasing industrial-size capacity. Table 5 lists installed equipment and horsepower rating of individual driving motors in the tipple. Figure 21 gives a schematic flow plan of the tipple.

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

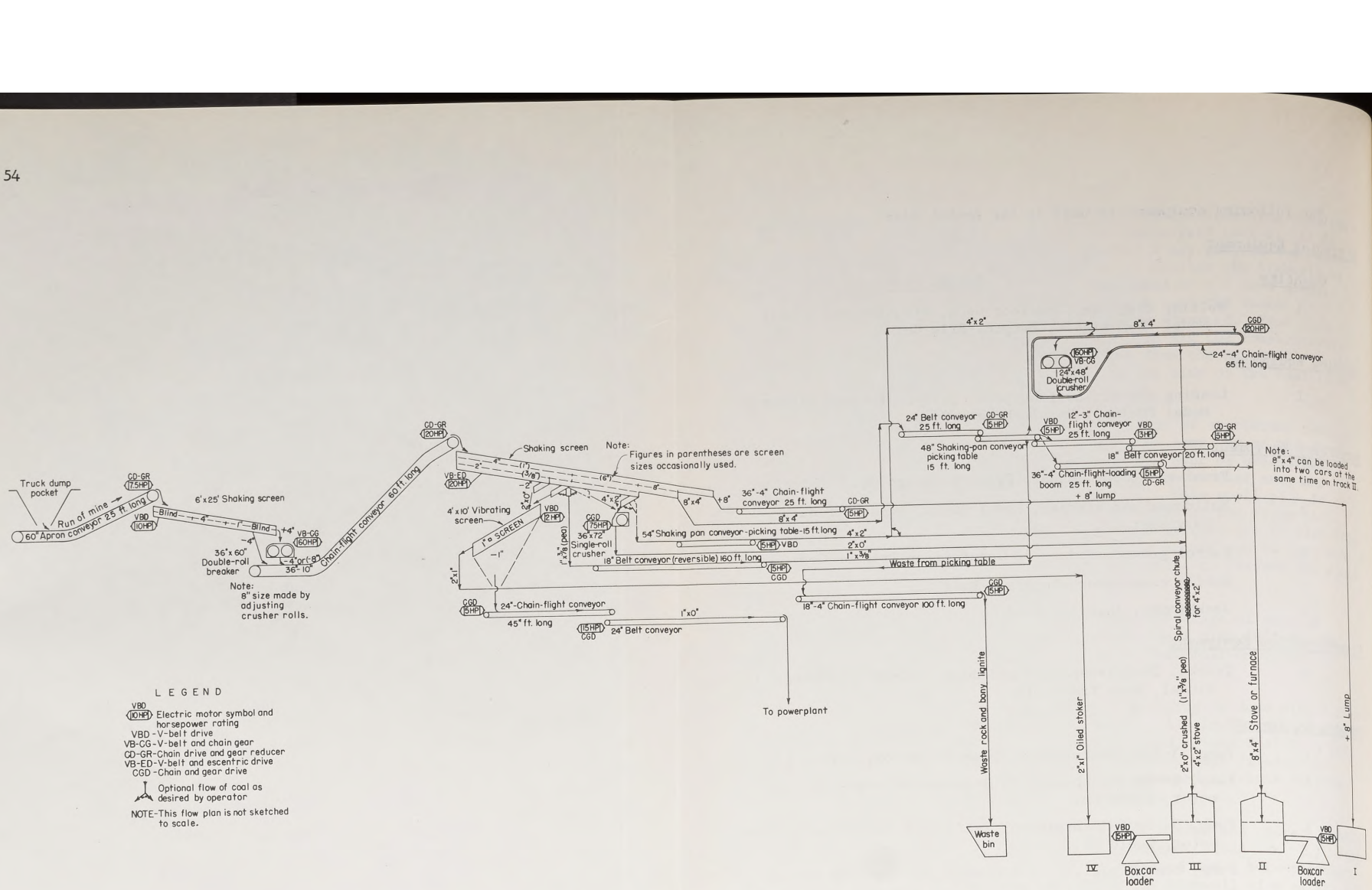

FIGURE 21. - Knife River Coal Mining Co., Lignite Preparation Plant Flow Plan, Beulah, Mercer County, N. Dak.

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 5. - Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Beulah mine

Equipment	Number	Rated hp.
Primary crushers	1	60
Secondary crushers	1	75
Do	1	60
Screens	1	10
Do	1	20
Do	1	2
Conveyors:		
Belt	1	15
Do	3	5
Apron or pan	1	7.5
Do	2	5
Chain-flight	2	20
Do	4	5
Do	1	3
Boxcar loaders and auxiliary equipment	2	5
Total	22	347.5

Truax-Traer Coal Co.

The Truax-Traer Coal Co. began operations in North Dakota in 1927 by purchasing the Kincaid mine. Four mines are now operated by the company in the lignite district in conjunction with larger operations in Eastern coalfields. Mining practices at each lignite mine are described. General supervision, management, and sales functions of the four North Dakota mines are centralized at a general office in Minot, N. Dak.

Custer Mine

The Custer mine was opened in 1946 in the Garrison Creek coal bed. It is about 6 miles east of Garrison, McLean County, N. Dak., and near the junction of U. S. Route 83 and State Highway 37. The mine is served by the Minneapolis, St. Paul & Sault Ste. Marie Railroad (Soo Line). The Custer mine was closed when it was visited in the summer of 1956, and complete mine data were not obtained. Less demand for industrial lignite by powerplants, a result of hydroelectric-power production at Garrison Dam, Riverdale, N. Dak., was primarily responsible for its closing. It is planned to reopen the mine when the demand for coal warrants it.

Twenty men were employed at the Custer mine when it was operated. Their duties and work schedules were similar to those of the Dakota Star mine, described later.

Daily coal production ranged from 700 to 1,800 tons. The average daily production for the report period (May 1955 through March 1956) was about 1,000 tons. The annual production from the mine for 1952 through 1956 follows:

Generated on 2024-09-21 17:44 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Year	Production, short tons
1952	299,822
1953	241,742
1954	287,717
1955	185,159
1956	183,504

The overburden at the Custer mine is 40 to 60 feet thick. It is predominantly argillaceous material containing inclusions of sandstone and 1 or 2 thin riders of lignite. Glacial sands, gravels, and boulders occur in the upper part of the overburden, covered by a thin mantle of soil.

Overburden is removed with a Marion 360 electric-powered shovel with a 10-cubic-yard bucket. A TX-310 Tower excavator was used for a time in the area of thickest overburden to remove the top 20 feet in a two-unit operation. In the declining market the two-unit operation was suspended and the area of minimum overburden exploited. The two-unit operation is described in detail later in this report when the Velva mine is discussed.

The coal bed is 5 to 6 feet thick and generally more firmly compacted than the lignite at other producing mines. In this area the coal beds are also aquifers. In winter freezing of water in the coal beds adds to the need for blasting for efficient loading. Drilling and blasting methods commonly used have been described previously.

Water is not plentiful at this mine, although it must be pumped continuously for about 8 months of the year. In winter, freezing generally lessens flow of mine water, and short periods of pumping are sufficient to control it.

Pit access ramps are constructed through the highwall at intervals of about 1,500 feet for the most direct haulage route to the tipple. A coal-berm road along the highwall side of the pit is provided to assure a dry haulage road above the pit bottom. Main and secondary haulage roads are surfaced with gravel from nearby large deposits. The maximum round-trip haul between the mine and the tipple is about 5 miles.

The following equipment was used in mining operations at the Custer mine:

Stripping Equipment

Quantity	Description
1	Revolving stripping shovel, 10-cubic-yard dipper, Model 360, Marion Power Shovel Co.
1	Tower excavator, 13-cubic-yard bucket, Model TX-310, Bucyrus-Erie Co.

Loading Equipment

1	Loading shovel, 3-1/2-cubic-yard dipper, Model 50-B, Bucyrus-Erie Co.

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Auxiliary Equipment

Quantity	Description
1	Bulldozer (scraper loader), Model D-8, Caterpillar Tractor Co.
1	Patrol, Model 12, Caterpillar Tractor Co.
1	Front-end loader, Frank S. Hough Co.
1	Truck, 5-ton capacity, Autocar Co.

Transportation Equipment

5	Trucks, 20-ton-capacity, bottom-dump, Model 27-FTD-83W, Euclid Div. General Motors Corp.

Pumping Equipment

4	Pumps, 3-inch-centrifugal, 20-hp., electric-motor-drive, 220-volt, 3-phase, Allis Chalmers Mfg. Co. and Gorman Rupp Co.

Revision and rearrangement of the existing tipple are contemplated to meet current changes in consumer demand.

Dakota Star Mine

The Dakota Star mine is about 4 miles north and 0.5 mile west, by road, from Hazen, Mercer County, N. Dak. This mine, served by the Northern Pacific Railroad, was opened in 1944 in the Beulah-Zap coal bed.

The annual production from the Dakota Star mine for 1952-56 follows:

Year	Production, short tons
1952	445,787
1953	397,261
1954	336,880
1955	320,153
1956	310,964

Twenty-one men are employed at the mine, including office and supervisory personnel. The production force of 17 men works full time, and their work is distributed between loading coal and stripping overburden, depending on demand for coal. The following schedule shows how the men are employed when the tipple is operated and when it is idle:

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Tipple operating	Tipple Idle
Electrician - 1	Electrician - 1
Tipplemen - 7	Tipplemen (cleaning and repairing) - 3
Euclid-truck operators - 7	Repairmen (in shop) - 2
Shovel operator - 1	Stripping (shovel and dragline operators, oilers, patrol, bulldozer operators) - 9
Oiler - 1	Drilling and blasting workers - 2

The daily production averages 2,600 tons of coal but ranges from 2,300 to 2,900 tons. If the mine were manned and operated at full capacity, over 3,000 tons of coal could be produced daily.

Coal is prospected for in advance of existing mine workings by company employees using the rotary drill. As at other mines, coal reserves equal to 2 to 4 years of mine production are blocked out by drilling.

Overburden in the north area of the mine has an average thickness of 30 feet and in the southwest area, 40 feet. It consists of argillaceous material covered by a thin mantle of glacial till. In some places a rider of lignite occurs about 10 feet below the surface. Sandstone lenses 3 to 6 feet thick and 15 to 30 feet long occur in the upper part of the overburden in the southwest area.

The overburden covering the northern part of the mine is stripped by a Bucyrus-Erie, Model 200W, dragline with a 110-foot boom and a 6-yard bucket. In the southwestern part it is removed by a Bucyrus-Erie, Model 320-B, shovel with a 90-foot boom, 62-foot dipper handle, and 10-cubic-yard bucket. Where the overburden is more than 40 feet thick, it is removed by a combined operation in which the dragline is followed by the stripping shovel (See figs. 22 and 23.)

The dragline, operating from the highwall on top of the overburden, removes the top 20 feet of overburden and casts it into the mined-out area. The rest of the overburden is then stripped by the shovel operating from the uncovered coal bed, casting behind the spoil pile built by the dragline. The bottom of the pit is initially excavated about 80 feet wide. Twenty feet of the exposed lignite is used as a haul road for trucks; the remaining 60 feet of the first strip uncovered is mined. Subsequent strips are established by removing the overburden over widths of 60 feet. Where the overburden is relatively thin - about 30 feet thick in the northern part and 40 feet thick in the southwestern part of the mine - a 90-foot-wide strip of lignite can be uncovered with existing equipment. The 70-foot-wide strip to be mined is then removed in 2 lifts.

The thickness of the coal bed ranges from 10 to 14 feet, averaging 12 feet. The thin rider of weathered lignite called leonardite, about 20 feet above the main lignite bed, is wasted with the overburden. Figure 5 shows its position in relation to the main bed. There is evidence of water drainage from the thin coal seam and down the highwall face of the pit.

Generated on 2024-09-21 17:47 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

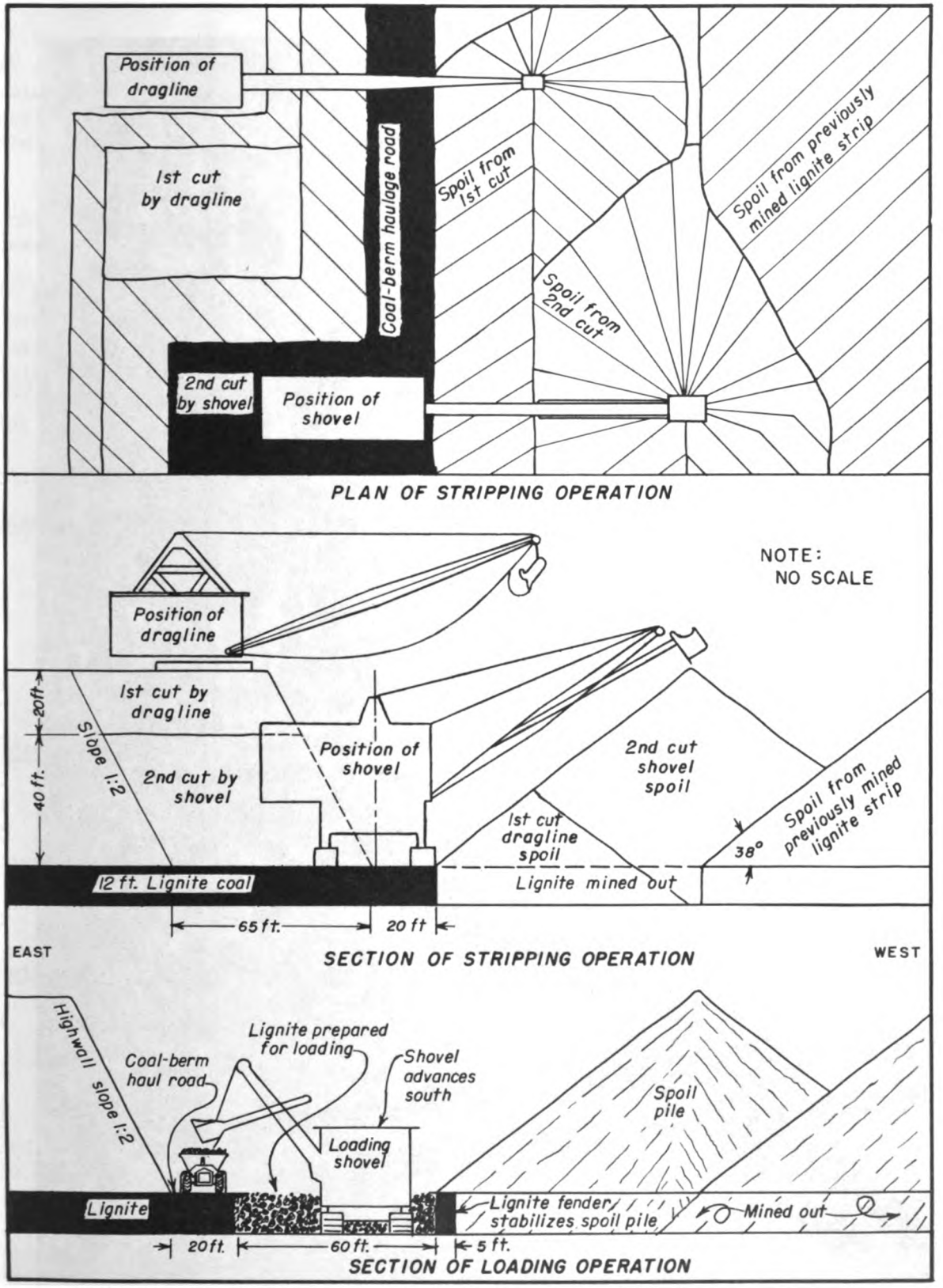

FIGURE 22. - Plan for Removing Overburden With Dragline and Shovel, Stripping in Tandem at Truax-Traer Coal Co. Dakota Star Mine Near Hazen, N. Dak.

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 3. - Distribution of direct mining costs, percent[1/]

	Labor	Supervision	Supplies, including power	Total
Stripping	52	6	42	100
Loading	58	3	39	100
Hauling	57	4	39	100
Preparation	60	9	31	100
Average	56	6	38	100

1/ Distribution prepared from cost data of 4 mines.

Forty-one men, including 2 supervisors, are employed at the Baukol-Noonan mine. Distribution of the employees among the various job classifications follows:

Classification	Number employed
Supervisor	2
Dragline and shovel operator	6
Oiler	6
Bulldozer operator	1
Euclid truckdriver	5
Tractor operator	1
Patrol operator	1
Electrician and mechanic	4
Tipple foreman	1
Tippleman, car dropper, common laborer	14

About 2,000 tons of coal is produced from the mine per 8-hour shift - equal to the tipple capacity of 250 tons per hour.

Contour strip mining has always been practiced at the Baukol-Noonan pit. Before 1945 a lignite-burning steam shovel was used to remove overburden. Since then an electric-powered dragline has been used. The track-haulage system from the pit to the preparation plant was replaced in 1949 by truck haulage.

Overburden consists chiefly of blue-gray to brownish-yellow argillaceous material containing sand lenses overlain by glacial till.

Two coal beds occur in the Fort Union formation near the Baukol-Noonan mine. The upper bed (10 to 40 feet below the surface) is lenticular and ranges in thickness from a few inches to as much as 3 feet. About 50 percent of this bed is weathered to a material locally called slack (more recently called leonardite). A small percentage of the slack has been mined and sold for mixing with drilling mud. Where it is 2 or more feet thick and not weathered, coal in the upper bed is mined for marketing. About 30 feet of material, predominantly blue-gray clay with sandstone lenses in the upper part, separates the lower and upper coal beds. Thickness of the lower coal bed averages 7 feet.

At times, about 2 feet above the bottom, a clay parting occurs that ranges in thickness from a few inches to as much as 1 foot. Below the lower lignite

Generated on 2024-09-21 17:46 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

bed is a bed of light-gray clay 6 to 10 feet thick. This clay is exploited as lightweight aggregate after being bloated in a rotary kiln.

About 10 prospect holes are drilled each year in advance of the mine workings. This program generally blocks out reserves that about equal the annual production. Drilling is done with churn drills, and coal samples are obtained by drive piping. Local well-drilling contractors are hired to drill at a rate of $1.75 per foot of hole. Figure 17 is a map of the mine and prospect-drill pattern.

Overburden is stripped with a Bucyrus-Erie, Monighan Model 9-W, walking dragline equipped with a 160-foot boom and a 10-cubic-yard bucket. Supported by a flat tub of considerable area, the walking dragline can operate safely on soft ground near coulees and on unconsolidated spoil piles. It may also be moved with ease on the paddle feet, which are of comparable area.

When both beds are recovered, the ratio of overburden to coal for the upper bed is 10 and to the lower bed 3. The stripping ratio in recovering only the lower bed is about 8. The dragline is operated initially from the top of the overburden on the highwall side of the pit. (See fig. 18.) Material above the top lignite bed is excavated toward the machine in the direction of the pit advance and parallel to the mined-out strip pit. The width of the excavation is about 110 feet. Spoil is cast into the area from which lignite has been mined in the adjacent strip. If the upper lignite bed is of good quality and recoverable, the first cut is made to the top of the coal. If not, the coal is spoiled with the waste rock. The dragline is advanced several hundred feet on this bench or as much as a thousand feet. It is then moved down a ramp, cut in the overburden by a bulldozer, and graded by a patrol to the top of the bench developed by the first phase of stripping.

In the second position a key cut or slot is made to establish alinement of the highwall parallel to the mined-out strip and to provide a starting point for the final operation. The key cut is dug about 10 feet wide at the bottom and 25 feet or more wide at the top, depending on the depth of overburden. Spoil from this second or key cut is cast behind the first pile toward the spoil from the previously mined strip. The spoil from these two cuts is then leveled by bulldozer and patrol grader for the third and last position of the dragline in the stripping operation. Smooth and relatively firm access ramps must be provided for the dragline to avoid upsetting it.

The third and last cut is made by dropping the bucket in the key cut, dragging it across the width of remaining overburden, and casting the spoil behind the dragline and on the leveled spoil piles. Close supervision and coordination are required to keep movements of the dragline to a minimum.

Most highwalls are dug on a 1 to 3 slope. To insure stability, where the overburden consists chiefly of loosely consolidated sands, gravels, and boulders, the slope must be maintained at 1 to 2 or less. The angle of repose of the spoil averages about 38°. The volume of material stripped from the lignite is estimated by the operators to increase about 20 percent when spoiled.

Generated on 2024-09-21 17:50 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

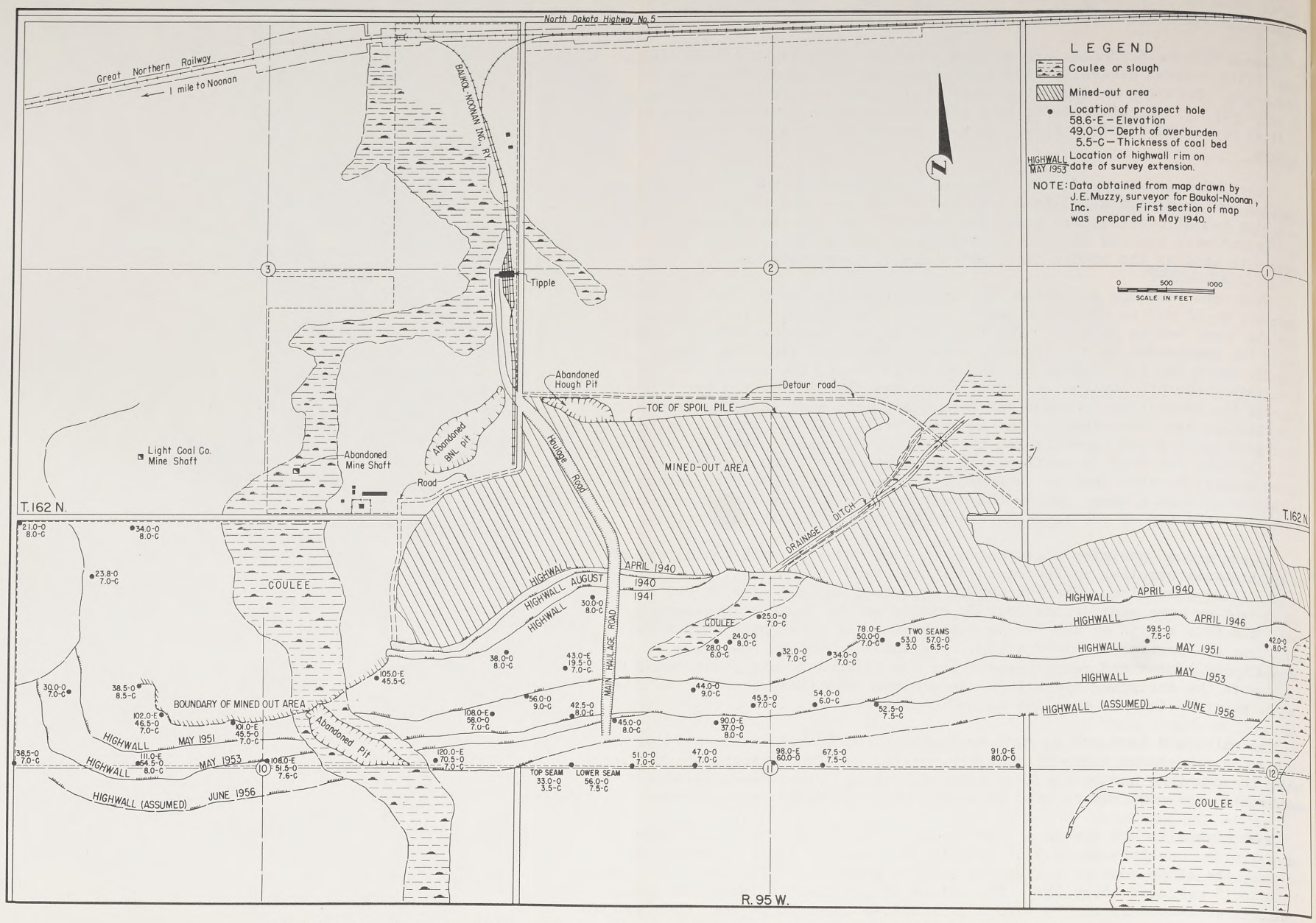

FIGURE 17. - Map of Baukol-Noonan, Inc., Open-Pit Lignite Mine Near Noonan, Divide County, N. Dak.

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

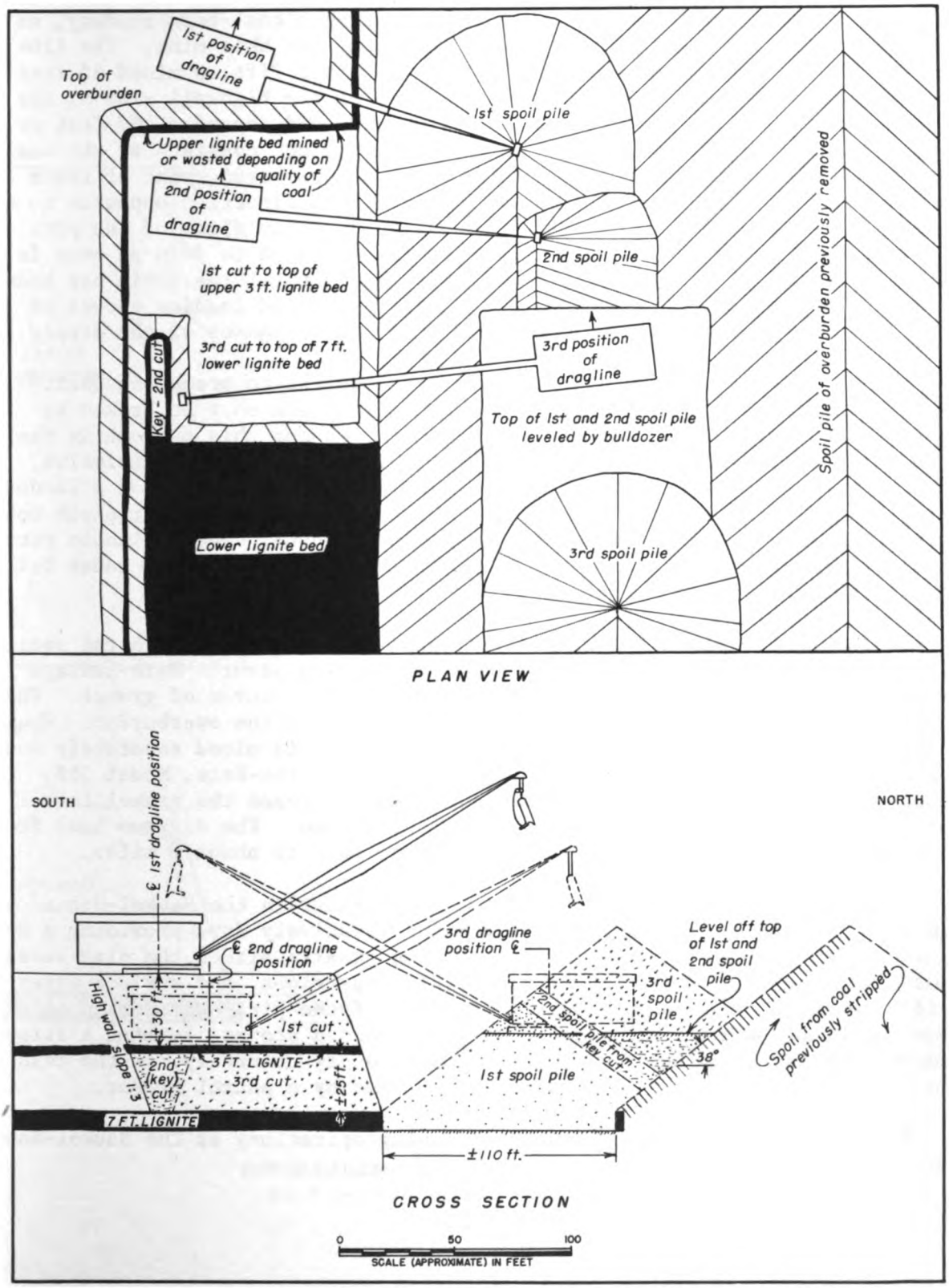

FIGURE 18. - Baukol-Noonan, Inc., Method of Strip Mining Two Lignite Coal Beds by Walking Dragline.

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

All stripped coal can be loaded without using a coal-berm roadway, as ground water is not present in appreciable amounts at this mine. The 110-foot-wide coal strip is mined in 3 lifts. The first lift is mined 45 feet wide and advanced about 400 feet along the toe of the highwall side of the pit. The second lift is mined about 32 feet wide and advanced 400 feet or even with the face of the first. The third lift mined consists of the coal next to the spoil pile. In some areas, where a loop arrangement of roads and ramps is not feasible, the third lift is mined in a direction opposite to the other lifts to provide minimum truck travel on the clay floor of the pit. (See fig. 19.) When the three lifts have been advanced to form an even face across the width of the pit, the cycle is repeated until the strip has been completely mined out. A 3-cubic-yard, electric-powered loading shovel is used that can fill the 20-ton-capacity trucks with 8 passes of the dipper.

Normally, drilling and blasting are not required to break the coal. In winter small areas in the coal occasionally freeze and must be broken by blasting. Only five cases of Stripkolex were used for this purpose in the winter of 1956. Stripkolex is a low-velocity, water-resistant explosive, heavy enough to sink readily. Blast holes are drilled by means of a Cardox Corp., portable, gasoline-engine-driven drill, fitted with a flat-pitch coal auger 2.5 inches in diameter and tungsten carbide bits. The drillhole pattern and blasting procedure are similar to those previously described under Drilling and Blasting Practice.

Access to the pit is provided over ramps constructed through the spoil pile as mining is advanced away from the preparation plant. Main-haulage roads are built with a base course of clay and a top course of gravel. The gravel is obtained from deposits in the upper part of the overburden. When a large deposit is encountered during stripping, it is mined separately and stockpiled beyond and near the pit highwall. A Bucyrus-Erie, Model 32B, diesel-powered shovel with a 1.5-cubic-yard dipper loads the gravel into Euclid trucks which transport it to the place of use. The maximum haul from the mine pit to the coal-preparation plant and back is about 7 miles.

Only a small amount of ground water accumulates in the Baukol-Noonan pit. Underclay exposed by mining the coal remains relatively dry, providing a good road surface. Summer showers and winter snow squalls affect the clay-surfaced roads only slightly. The clay is relatively impervious, and surface water rapidly drains to the sumps and is pumped out of the pit. Moisture penetrates a few inches below the clay surface during extended storms, forming a slippery roadway. The road surface is either allowed to dry naturally, or the thin skin of moist, slick clay is scraped to the side by a patrol grader.

The following equipment is used in mining operations at the Baukol-Noonan mine:

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

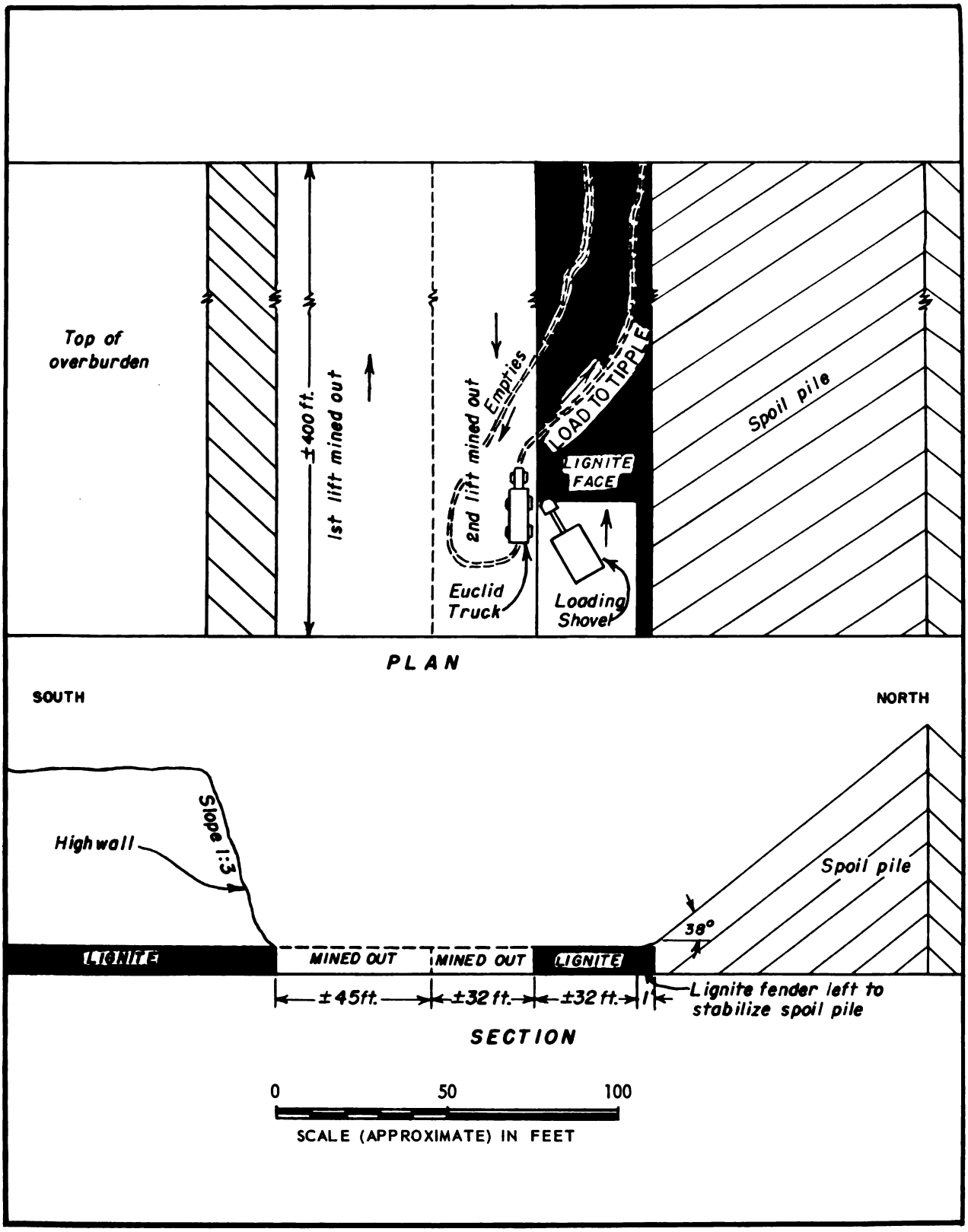

FIGURE 19. - Baukol-Noonan, Inc., Method of Mining Lignite Coal.

Generated on 2024-09-21 17:45 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Stripping Equipment

Quantity	Description
1	Walking dragline, 160-foot boom, 10-cubic-yard bucket, Model 9W-Monighan, Bucyrus-Erie Co.

Loading Equipment

1	Electric loading shovel, 34-foot boom, 3-cubic-yard dipper, Model 50-B, Bucyrus-Erie Co.
1	Diesel loading shovel, 1.5-cubic-yard dipper, Model 32-B, Bucyrus-Erie Co.

Auxiliary Equipment

2	Bulldozers, Model D-7, Caterpillar Tractor Co.
1	Front-end loader, Payloader, F. G. Hough Co.
1	Patrol grader, Model 112, Caterpillar Tractor Co.
1	Tractor, Model HD-5, Caterpillar Tractor Co.
1	Tractor scraper, Model W-6, International Harvester Co.
1	Portable drill, gasoline motor, Cardox Corp.

Transportation Equipment

5	Trucks, 20-ton-capacity, bottom-dump, Model 27-FTD-83W, Euclid Div. General Motors Corp.
1	Truck, 2-ton-capacity.
1	Pickup truck, 0.5-ton-capacity
1	Pickup truck, 0.75-ton-capacity.

Pumping Equipment

1	Pump, 2-stage-centrifugal, 1.5-inch-discharge, 15-hp., electric motor, Fairbanks-Morse & Co.
2	Pumps, 2-stage-impeller, 2-inch-discharge, 20-hp., Electric motor, McNally-Pittsburgh Mfg. Co.
2	Pumps, 1-stage-impeller, 2-inch-discharge, 20-hp., electric motor, McNally-Pittsburgh Mfg. Co.
1	Pump, centrifugal, 1.5-inch-discharge, 10-hp., gasoline motor, Gorman Rupp Co.
1	Pump, centrifugal, 1.5-inch-discharge, 10-hp., electric motor, Gorman Rupp Co.
2	Pumps, dual-prime-centrifugal, 1.5-inch-discharge, 7.5-hp., gasoline motor, Construction Machinery Co.

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

When the tipple was built in 1930, it was designed to supply a market for plus-2-inch-sizes. The original tipple has been altered from time to time, as the market for sized coal has changed. Now, coal prepared at the Baukol-Noonan tipple is broadly classified by the operator as domestic (plus-2-inch size) and industrial (minus-2-inch size). During the period covered by this report, 30.5 percent of the coal was prepared for domestic and 69.5 percent for industrial use.

The domestic coal is divided into two classes: (1) Stove and furnace and (2) domestic stoker. These sizes constitute 15.7 and 14.8 percent, respectively, of the total preparation-plant production. Table 4 lists installed equipment and horsepower rating of individual driving motors in the tipple. Figure 20 gives a schematic flow plan of the tipple.

TABLE 4. - Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Baukol-Noonan mine

Equipment	Number	Rated hp.
Primary crushers	1	75
Secondary crushers	1	50
Screens	1	35
Do	1	7.5
Do	1	5
Conveyors:		
Belts	1	15
Do	1	10
Apron or pan	1	50
Do	1	25
Do	1	10
Chain-flight	2	7.5
Do	1	10
Do	1	15
Do	1	5
Bucket elevators	1	15
Do	1	7.5
Boxcar loaders and auxiliary equipment	1	7.5
Do	2	5
Railroad-car hauls	1	25
Do	1	20
Do	4	10
Total	26	452.5

Knife River Coal Mining Co.

Beulah Mine

Knife River Coal Mining Co. is a subsidiary of the Montana-Dakota Utilities Co. Its Beulah mine is about 5 miles north of Beulah, Mercer County, N. Dak., and just south of State Highway 7. The property was first exploited as an underground mine opened in the Beulah-Zap coal bed in 1918. Contour strip mining was begun in 1950, and by 1952 all coal was being mined from open pits.

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

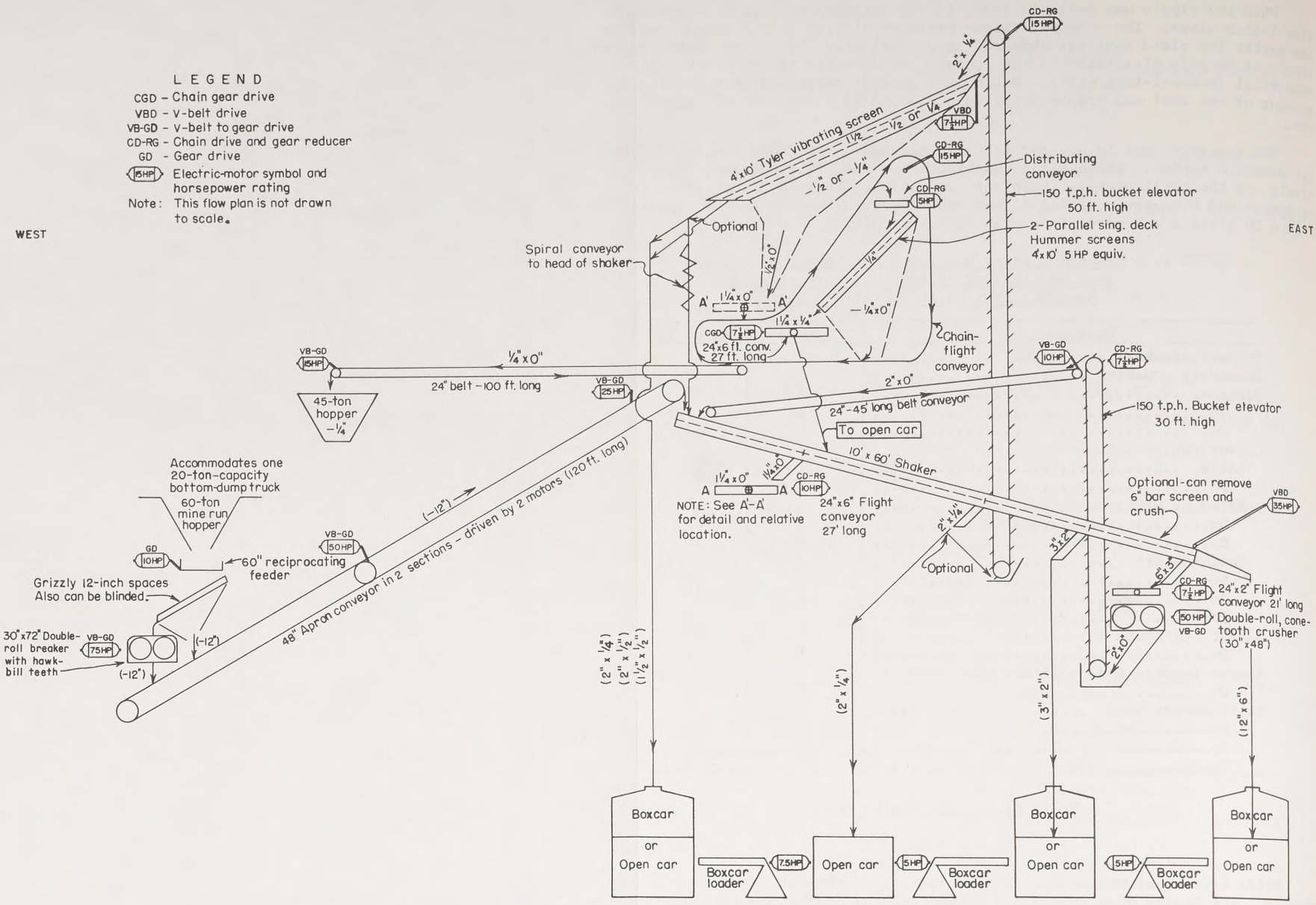

FIGURE 20. - Flow Plan of Baukol-Noonan, Inc., Lignite Preparation Plant, Noonan, Divide County, N. Dak.

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The annual production of coal from the Beulah mine for 1952-56 follows:

Year	Production, short tons
1952	380,408
1953	311,173
1954	333,832
1955	379,986
1956	366,195

Forty-four men are employed at the Beulah mine, including office and supervisory forces. The number employed and job classifications follow:

Classification	Number employed
Supervisor	3
Office personnel	3
Dragline operator	3
Oiler	3
Loading-shovel operator	1
Oiler	1
Bulldozer operator	1
Truckdriver	5
Mechanic	2
Truck maintenanceman	2
Surface, common laborer	3
Tipple operator, car dropper, oiler, etc.	17

The preparation plant was operated for 228 shifts during the report period; the fiscal year ended June 30, 1956. A total of 366,195 tons of coal was produced during the period, an average of about 1,600 tons per 8-hour shift.

The thickness of overburden ranges from 30 to 65 feet and averages about 45 feet. The thickest overburden occurs at the west end of the property. A blue-gray clay usually occurs immediately above the Beulah-Zap coal bed. In places, erosion has removed the clay bed, and younger glacial deposits now lie unconformably upon the coal. Where the clay is not eroded, underlying coal is of good quality; however, beneath the glacial till the coal usually is weathered at the top and often through its entire thickness. In some places the coal bed has been eroded away entirely. A layer of sandstone concretions occurs about 15 feet below the surface in the west pit. In places the concretions are only a few inches in diameter; in others, they may be several feet in diameter and several hundred feet in length. This hard material is drilled and blasted so that it can be moved easily with the dragline.

The coal bed is 12 to 18 feet thick and dissected by tributary streams of the Knife River. Locally, the bed is in an elongated spur hill that trends southerly. Coal outcrops around the hill, and the two contour strip pits have been developed along the west and east edges of the deposit. Each of these pits is about 0.75 mile long.

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The overburden is stripped with a Bucyrus-Erie Monighan walking dragline (Model 7W), equipped with a 160-foot boom and a 6-cubic-yard bucket. It is removed in a 100-foot-wide strip in 2 steps. First, a key cut, 25 feet wide or more, is dug to the surface of the lignite bed to develop the highwall of the new contour strip pit. The highwall is established at a 1 to 3 slope. The dragline is operated from the undisturbed surface, and the bucket is pulled in the direction toward which the pit is being advanced. From this position a direct pull can be applied to the bucket to dig the comparatively solid overburden without blasting it first. Waste from the key cut is spilled into the mined-out area to form a small pile along the side of the coal to be stripped.

The second step is to remove the 75-foot-wide spur of overburden remaining between the key cut and the mined-out strip.in the same way as the first cut was developed with the dragline operating from the spur of overburden being removed. However, in this operation the waste can be cast over and behind the small spoil pile derived from the key cut. This spoil pile is built up until the slope facing the pit merges with that of the first pile. An advantage to building the spoil pile in two stages is that the initial pile from the key cut can settle before the spoil from the second cut is cast behind and onto it; thus, it stabilizes the whole mass and helps to prevent the spoil from sliding to the stripped lignite surface.

As at all mines, the pits are laid out to take advantage of outside curves. Straight-line pits are acceptable, but the ideal plan includes as many outside curves as the topography will allow so that maximum space for spoil is provided.

The coal is broken for loading by blasting. Drilling is done with a company-made drill, powered by a gasoline-driven motor. A 2-inch-diameter coal auger fitted with "Master" throwaway drill bits is used. Lump Coal C, a permissible explosive, detonated by electric delay blasting caps fired by a blasting machine, is used to break the coal. The square-drill-hole pattern and blasting procedure have been described previously.

The end-dump trucks used at the Beulah mine are loaded and operated while they are on a coal-berm road along the strip being mined. (See fig. 7.) Each pit has 4 access ramps, 1,300 feet apart - 1 at each end and 2 between these end ramps. The ramps at the east pit cut through the highwall side of the pit to shorten the haul, and the ramps at the west pit cut through the spoil pile.

Ramps and main-haulage roads to the preparation plant are surfaced with a mixture of about 1 part raw clay and 3 parts natural-burned clay (scoria), which occurs extensively in the area. The maximum round-trip haul between the mine and the tipple adjacent to the powerplant at the east edge of Beulah is 7.5 miles.

Because the coal bed mined at Beulah is within a narrow spur, which is well drained by natural draws, ground water is not a problem. Surface water is adequately intercepted by dikes and ditches, and the small runoff that flows into the pit is pumped out easily.

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The following equipment is used at the Beulah mine:

Stripping Equipment

Quantity	Description
1	Walking dragline, 160-foot boom, 6-cubic-yard bucket, Model 7W-Monighan, Bucyrus-Erie Co.

Loading Equipment

1	Loading shovel, 60-foot boom, 3.75-cubic-yard dipper, Model PH-1400, Harnischfeger Corp.

Auxiliary Equipment

1	Front-end scoop loader, Frank S. Hough Co.
1	Bulldozer and scraper, Model TD-24, International Harvester Co.
1	Patrol grader, Model 12, Caterpillar Tractor Co.
1	Mobile compressor, Ingersol-Rand Co.
1	Jackhammer, Ingersol-Rand Co.

Transportation Equipment

6	Trucks, 20-ton-capacity end-dump, 200-hp., Cummings diesel, Mack Truck, Inc.

Pumping Equipment

1	Pump, 3-inch-centrifugal, gasoline-motor, Gorman Rupp Co.
1	Pump, 6- by 6-inch-piston, 3-inch-discharge, electric motor, Gould Co.
1	Pump, 5- by 5-inch-piston, 2-1/2-inch-discharge, electric motor, Gould Co.
1	Pump, centrifugal, 4-inch-discharge, electric motor.
1	Pump, portable-centrifugal, 1-1/2-inch-discharge, gasoline motor, Gorman Rupp Co.

As at the Noonan mine the tipple was originally designed to supply a market largely domestic. Picking tables were provided to remove the bony coal and other impurities peculiar to the Beulah-Zap bed. The original tipple has been altered as necessary to provide for increasing industrial-size capacity. Table 5 lists installed equipment and horsepower rating of individual driving motors in the tipple. Figure 21 gives a schematic flow plan of the tipple.

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

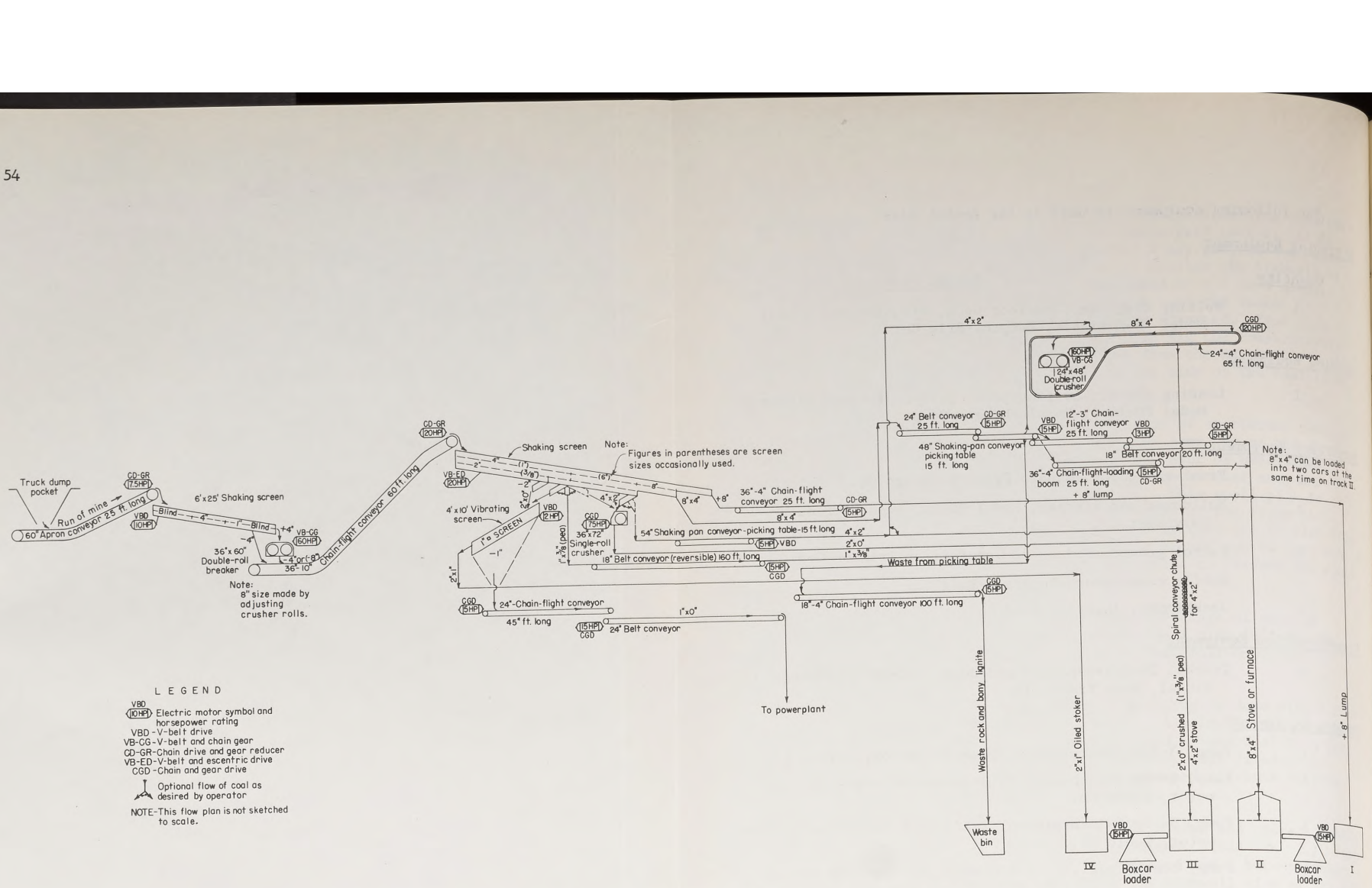

FIGURE 21. - Knife River Coal Mining Co., Lignite Preparation Plant Flow Plan, Beulah, Mercer County, N. Dak.

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 5. - Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Beulah mine

Equipment	Number	Rated hp.
Primary crushers	1	60
Secondary crushers	1	75
Do.	1	60
Screens	1	10
Do.	1	20
Do.	1	2
Conveyors:		
Belt	1	15
Do.	3	5
Apron or pan	1	7.5
Do.	2	5
Chain-flight	2	20
Do.	4	5
Do.	1	3
Boxcar loaders and auxiliary equipment	2	5
Total	22	347.5

Truax-Traer Coal Co.

The Truax-Traer Coal Co. began operations in North Dakota in 1927 by purchasing the Kincaid mine. Four mines are now operated by the company in the lignite district in conjunction with larger operations in Eastern coalfields. Mining practices at each lignite mine are described. General supervision, management, and sales functions of the four North Dakota mines are centralized at a general office in Minot, N. Dak.

Custer Mine

The Custer mine was opened in 1946 in the Garrison Creek coal bed. It is about 6 miles east of Garrison, McLean County, N. Dak., and near the junction of U. S. Route 83 and State Highway 37. The mine is served by the Minneapolis, St. Paul & Sault Ste. Marie Railroad (Soo Line). The Custer mine was closed when it was visited in the summer of 1956, and complete mine data were not obtained. Less demand for industrial lignite by powerplants, a result of hydroelectric-power production at Garrison Dam, Riverdale, N. Dak., was primarily responsible for its closing. It is planned to reopen the mine when the demand for coal warrants it.

Twenty men were employed at the Custer mine when it was operated. Their duties and work schedules were similar to those of the Dakota Star mine, described later.

Daily coal production ranged from 700 to 1,800 tons. The average daily production for the report period (May 1955 through March 1956) was about 1,000 tons. The annual production from the mine for 1952 through 1956 follows:

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Year	Production, short tons
1952	299,822
1953	241,742
1954	287,717
1955	185,159
1956	183,504

The overburden at the Custer mine is 40 to 60 feet thick. It is predominantly argillaceous material containing inclusions of sandstone and 1 or 2 thin riders of lignite. Glacial sands, gravels, and boulders occur in the upper part of the overburden, covered by a thin mantle of soil.

Overburden is removed with a Marion 360 electric-powered shovel with a 10-cubic-yard bucket. A TX-310 Tower excavator was used for a time in the area of thickest overburden to remove the top 20 feet in a two-unit operation. In the declining market the two-unit operation was suspended and the area of minimum overburden exploited. The two-unit operation is described in detail later in this report when the Velva mine is discussed.

The coal bed is 5 to 6 feet thick and generally more firmly compacted than the lignite at other producing mines. In this area the coal beds are also aquifers. In winter freezing of water in the coal beds adds to the need for blasting for efficient loading. Drilling and blasting methods commonly used have been described previously.

Water is not plentiful at this mine, although it must be pumped continuously for about 8 months of the year. In winter, freezing generally lessens flow of mine water, and short periods of pumping are sufficient to control it.

Pit access ramps are constructed through the highwall at intervals of about 1,500 feet for the most direct haulage route to the tipple. A coal-berm road along the highwall side of the pit is provided to assure a dry haulage road above the pit bottom. Main and secondary haulage roads are surfaced with gravel from nearby large deposits. The maximum round-trip haul between the mine and the tipple is about 5 miles.

The following equipment was used in mining operations at the Custer mine:

Stripping Equipment

Quantity	Description
1	Revolving stripping shovel, 10-cubic-yard dipper, Model 360, Marion Power Shovel Co.
1	Tower excavator, 13-cubic-yard bucket, Model TX-310, Bucyrus-Erie Co.

Loading Equipment

1	Loading shovel, 3-1/2-cubic-yard dipper, Model 50-B, Bucyrus-Erie Co.

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Auxiliary Equipment

Quantity	Description
1	Bulldozer (scraper loader), Model D-8, Caterpillar Tractor Co.
1	Patrol, Model 12, Caterpillar Tractor Co.
1	Front-end loader, Frank S. Hough Co.
1	Truck, 5-ton capacity, Autocar Co.

Transportation Equipment

5	Trucks, 20-ton-capacity, bottom-dump, Model 27-FTD-83W, Euclid Div. General Motors Corp.

Pumping Equipment

4	Pumps, 3-inch-centrifugal, 20-hp., electric-motor-drive, 220-volt, 3-phase, Allis Chalmers Mfg. Co. and Gorman Rupp Co.

Revision and rearrangement of the existing tipple are contemplated to meet current changes in consumer demand.

Dakota Star Mine

The Dakota Star mine is about 4 miles north and 0.5 mile west, by road, from Hazen, Mercer County, N. Dak. This mine, served by the Northern Pacific Railroad, was opened in 1944 in the Beulah-Zap coal bed.

The annual production from the Dakota Star mine for 1952-56 follows:

Year	Production, short tons
1952	445,787
1953	397,261
1954	336,880
1955	320,153
1956	310,964

Twenty-one men are employed at the mine, including office and supervisory personnel. The production force of 17 men works full time, and their work is distributed between loading coal and stripping overburden, depending on demand for coal. The following schedule shows how the men are employed when the tipple is operated and when it is idle:

Generated on 2024-09-21 17:53 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Tipple operating	Tipple Idle
Electrician - 1	Electrician - 1
Tipplemen - 7	Tipplemen (cleaning and repairing) - 3
Euclid-truck operators - 7	Repairmen (in shop) - 2
Shovel operator - 1	Stripping (shovel and dragline operators, oilers, patrol, bulldozer operators) - 9
Oiler - 1	Drilling and blasting workers - 2

The daily production averages 2,600 tons of coal but ranges from 2,300 to 2,900 tons. If the mine were manned and operated at full capacity, over 3,000 tons of coal could be produced daily.

Coal is prospected for in advance of existing mine workings by company employees using the rotary drill. As at other mines, coal reserves equal to 2 to 4 years of mine production are blocked out by drilling.

Overburden in the north area of the mine has an average thickness of 30 feet and in the southwest area, 40 feet. It consists of argillaceous material covered by a thin mantle of glacial till. In some places a rider of lignite occurs about 10 feet below the surface. Sandstone lenses 3 to 6 feet thick and 15 to 30 feet long occur in the upper part of the overburden in the southwest area.

The overburden covering the northern part of the mine is stripped by a Bucyrus-Erie, Model 200W, dragline with a 110-foot boom and a 6-yard bucket. In the southwestern part it is removed by a Bucyrus-Erie, Model 320-B, shovel with a 90-foot boom, 62-foot dipper handle, and 10-cubic-yard bucket. Where the overburden is more than 40 feet thick, it is removed by a combined operation in which the dragline is followed by the stripping shovel (See figs. 22 and 23.)

The dragline, operating from the highwall on top of the overburden, removes the top 20 feet of overburden and casts it into the mined-out area. The rest of the overburden is then stripped by the shovel operating from the uncovered coal bed, casting behind the spoil pile built by the dragline. The bottom of the pit is initially excavated about 80 feet wide. Twenty feet of the exposed lignite is used as a haul road for trucks; the remaining 60 feet of the first strip uncovered is mined. Subsequent strips are established by removing the overburden over widths of 60 feet. Where the overburden is relatively thin - about 30 feet thick in the northern part and 40 feet thick in the southwestern part of the mine - a 90-foot-wide strip of lignite can be uncovered with existing equipment. The 70-foot-wide strip to be mined is then removed in 2 lifts.

The thickness of the coal bed ranges from 10 to 14 feet, averaging 12 feet. The thin rider of weathered lignite called leonardite, about 20 feet above the main lignite bed, is wasted with the overburden. Figure 5 shows its position in relation to the main bed. There is evidence of water drainage from the thin coal seam and down the highwall face of the pit.

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

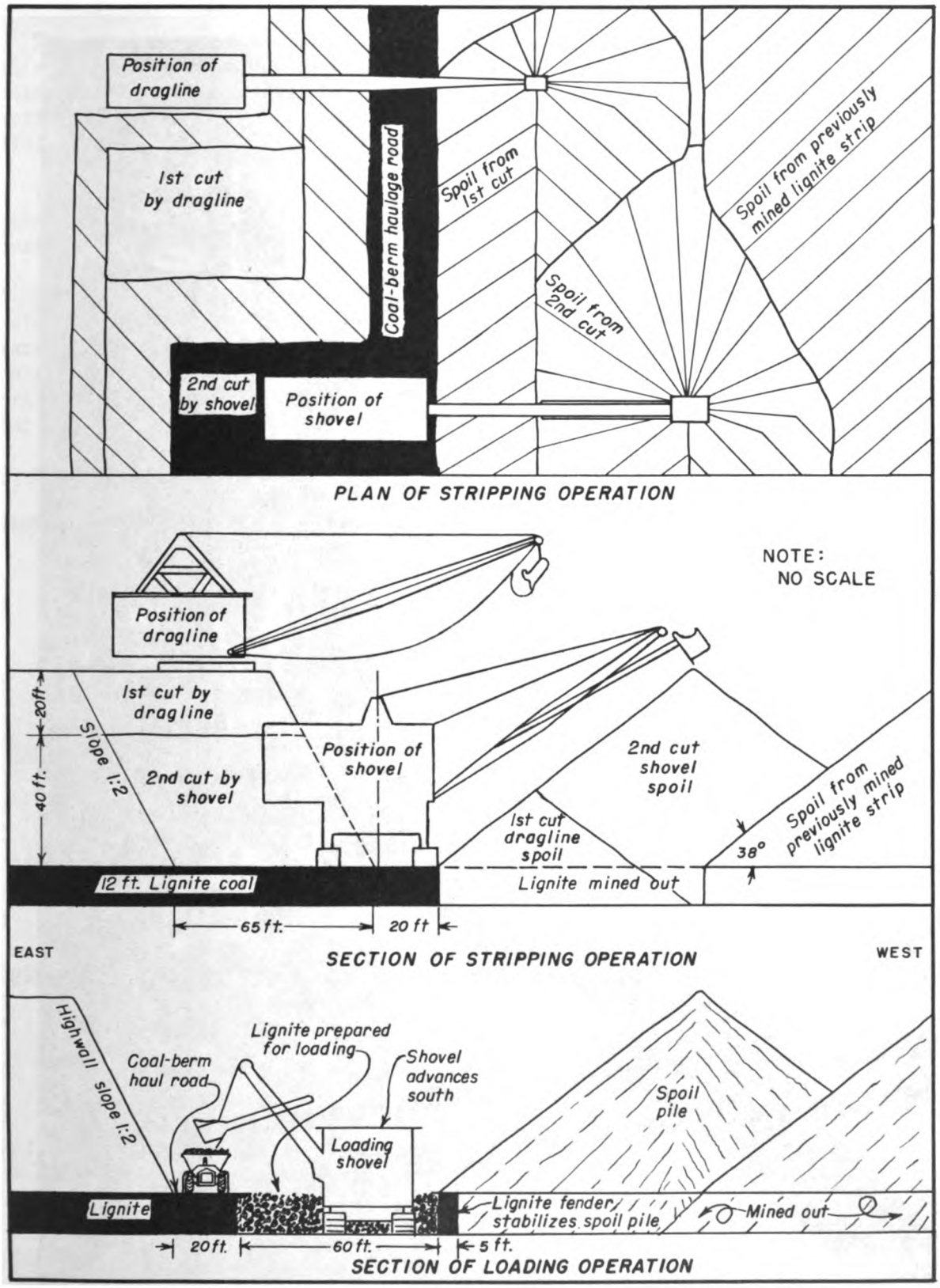

FIGURE 22. - Plan for Removing Overburden With Dragline and Shovel, Stripping in Tandem at Truax-Traer Coal Co. Dakota Star Mine Near Hazen, N. Dak.

Generated on 2024-09-21 17:42 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

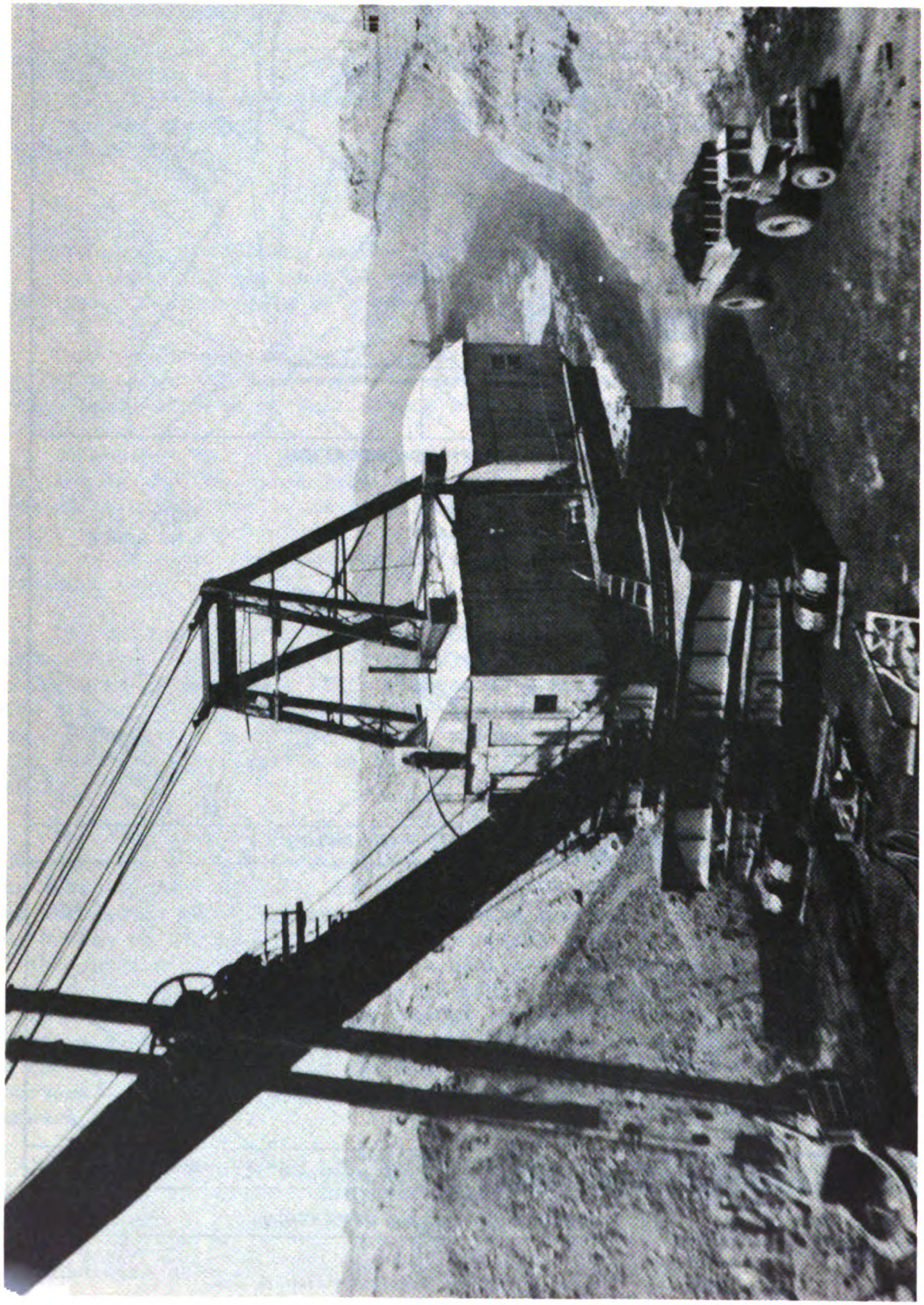

FIGURE 23. - Stripping Shovel, 10-Cubic-Yard Dipper, Dakota Star Mine, Truax-Traer Coal Co.

Generated on 2024-09-21 17:54 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from
THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Two men prepared the coal for loading by drilling and blasting. Broken coal equal to that loaded in each shift usually is maintained between the loading shovel and the drilling crew. The general drilling pattern and blasting practice have been described previously. Five passes of the loading shovel are required to fill a 20-ton-capacity truck.

In winter mine water freezes, and pumping is unnecessary for about 4 months of the year. During the remaining 8 months moderate pumping is necessary to empty the pit sumps.

Pit access ramps at this mine are excavated through the highwall side to shorten the distance to the tipple because the pit is being advanced in the direction of the preparation plant. Main haulage roads from the pit to the tipple are surfaced with gravel. Secondary mine roads are surfaced with scoria. The round trip from the southwest mining area to the preparation plant is 2.5 miles; from the north mining area the round trip is 5 miles.

Equipment used in mining operations at Dakota Star mine is as follows:

Stripping Equipment

Quantity	Description
1	Walking dragline, 110-foot boom, 6-cubic-yard bucket, Model 200-W, Bucyrus-Erie Co.
1	Revolving shovel, 10-cubic-yard dipper, Model 320-B, Bucyrus-Erie Co.

Loading Equipment

1	Electric loading shovel, 5-cubic-yard bucket, Model 85-B, Bucyrus-Erie Co.

Transportation Equipment

8	Trucks, 20-ton-capacity, bottom-dump, Model 27-FTD-83W, Euclid Div. General Motors Corp.

Pumping Equipment

3	Pumps, 3-inch-centrifugal, 20-hp., electric motor, 440-volt, 3 phase, Allis Chalmers Mfg. Co. and Gorman Rupp Co.

The preparation plant has facilities for producing the complete range of sized products for domestic and industrial consumers. Figure 24 is a schematic flow plan of the tipple at Dakota Star mine. Table 6 lists the installed equipment and rated horsepower of individual driving motors.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

FIGURE 24. - Flow Plan of Dakota Star Mine Preparation Plant, Truax-Traer Coal Co., Near Hazen, Mercer County, N. Dak.

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 6. - Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Dakota Star mine

Equipment	Number	Rated hp.
Primary crushers	1	75
Secondary crushers	1	40
Do.	1	100
Do.	1	50
Screens	1	40
Do.	1	15
Do.	2	10
Conveyors:		
Belt	1	30
Do.	2	10
Apron or pan	1	30
Do.	1	20
Do.	2	5
Chain-flight	1	15
Do.	1	50
Do.	3	10
Do.	1	40
Do.	1	25
Do.	3	7.5
Boxcar loaders and auxiliary equipment	1	20
Do.	4	10
Do.	1	7.5
Do.	6	3
Do.	1	5
Total	38	723.0

Kincaid Mine

The Kincaid mine (in the Noonan coal bed) is about 5 miles south of Columbus, Burke County, N. Dak. A spur railroad (4 miles long), owned and operated by Truax-Traer Coal Co., connects the mine with the Great Northern Railroad. Truax Brothers opened the mine originally in 1920. In 1927 Truax-Traer Coal Co., which was formed that same year, purchased it.

The annual production of lignite from the Kincaid mine for 1952-56 was as follows:

Year	Production, short tons
1952	418,243
1953	409,081
1954	400,107
1955	459,727
1956	485,567

Fifty-one men are employed at this mine. At the other Truax-Traer mines fewer men are employed, because the current decrease in demand for coal has

Generated on 2024-09-21 17:51 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

partly curtailed these mines' operations. Job classifications and number employed for each job at the Kincaid mine follow:

Classification		Number employed
	Mine Employees	
Stripping operation	Shovel and dragline operator	3
	Oiler	3
Loading operation	Shovel operator	2
	Oiler	2
	Euclid truckdriver	8
	Patrol operator	1
	Bulldozer operator	2
	Pump operator	1
	Shot firer	1
	Preparation-Plant Employees	
	Foreman	1
	Operator	1
	Oiler	1
	Railroad car loader	3
	Railroad car dropper	1
	Railroad car starter (crab operator)	1
	Machine-Shop Employees	
	Mechanic	1
	Welder	2
	Electrician	1
	Carpenter-Shop Employees	
	Carpenter	1
	Camp maintenanceman	1
	Company-Railroad Employees	
	Engineer	1
	Brakeman	1
	Fireman	1
	Track boss	1
	Track helper	1
	Car cleaner	2
	Supervisors and Other Employees	
	Supervisor	2
	Office clerk	2
	Watchman	3

An average of 2,500 tons of coal per operating day is produced from the Kincaid mine. The daily production ranges from 2,300 to 2,900 tons. The larger daily tonnage generally is produced when the mine is operated 25 or 26 days a month.

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Two coal beds are mined at this property. About 20 feet of argillaceous material overlies the upper lignite bed, and about 35 feet of similar material lies between it and the lower lignite bed. Sandstone lenses occur in the lower burden, and large boulders and lenses of sand and gravel are near the surface in the upper overburden.

A typical section of the upper lignite bed is as follows:

	Feet
Coal	2.0
Clay, gray	1.5-2.0
Coal	2.0
Sandstone	0-0.5
Coal	4.0-5.0

The top 2.0 feet of coal and the 1.5 to 2.0 feet of gray clay are removed and wasted with the overburden. The remaining 6 to 7 feet of coal, containing the 0.5-foot sandstone parting, is mined. The lower lignite bed is about 8 feet thick and is mined after the upper coal bed has been extracted and the separating 35 feet of burden has been removed.

Ground ahead of the existing mine workings is prospected with a rotary drill. Measured coal reserves, equal to 2 to 4 years of production, are maintained. Figure 25 shows the mine plan and prospecting pattern.

A Marion walking dragline, model 7400, with a 12-cubic-yard bucket and 175-foot boom, and a Bucyrus-Erie model 375-B revolving stripping shovel with a 10-cubic-yard dipper, 90-foot boom, and a 62-foot dipper handle are used in combination to remove overburden at the Kincaid mine. In the upper bed the 7 feet of recoverable lignite has a ratio of overburden to coal thickness of about 3. Despite the low ratio, mining is not as simple as indicated, because the lignite must be removed in two operations to eliminate the sandstone parting.

Figure 26 shows the several phases of the mining process. The initial cut to the upper bed is made with the dragline from a position near the highwall of the strip previously mined out. Operating on a 50-foot-wide spur (from the edge of the old highwall), a 150-foot-wide cut is made by dragging the bucket perpendicularly to the line of pit advance. Waste is cast into the area from which coal has been mined by swinging the boom about 130°. The dragline completes a digging cycle in about 45 seconds. The 150-foot-wide cut is advanced several hundred feet.

In the second position the dragline operates from the leveled spoil pile of the first operation to remove the 50-foot-wide spur. Waste is cast on top of the leveled spoil but behind the dragline. These two operations clear the upper bed for subsequent mining.

After the upper bed has been mined, the dragline is moved from the spoil piles to the bench, where the burden over the lower seam must be removed. In the third operation the dragline makes a 70-foot-wide cut next to the mined-out area by dragging the bucket in the direction of pit advance. Overburden

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435043530643415
Public Domain, Google-digitized / http://www.hathitrust.org/access use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

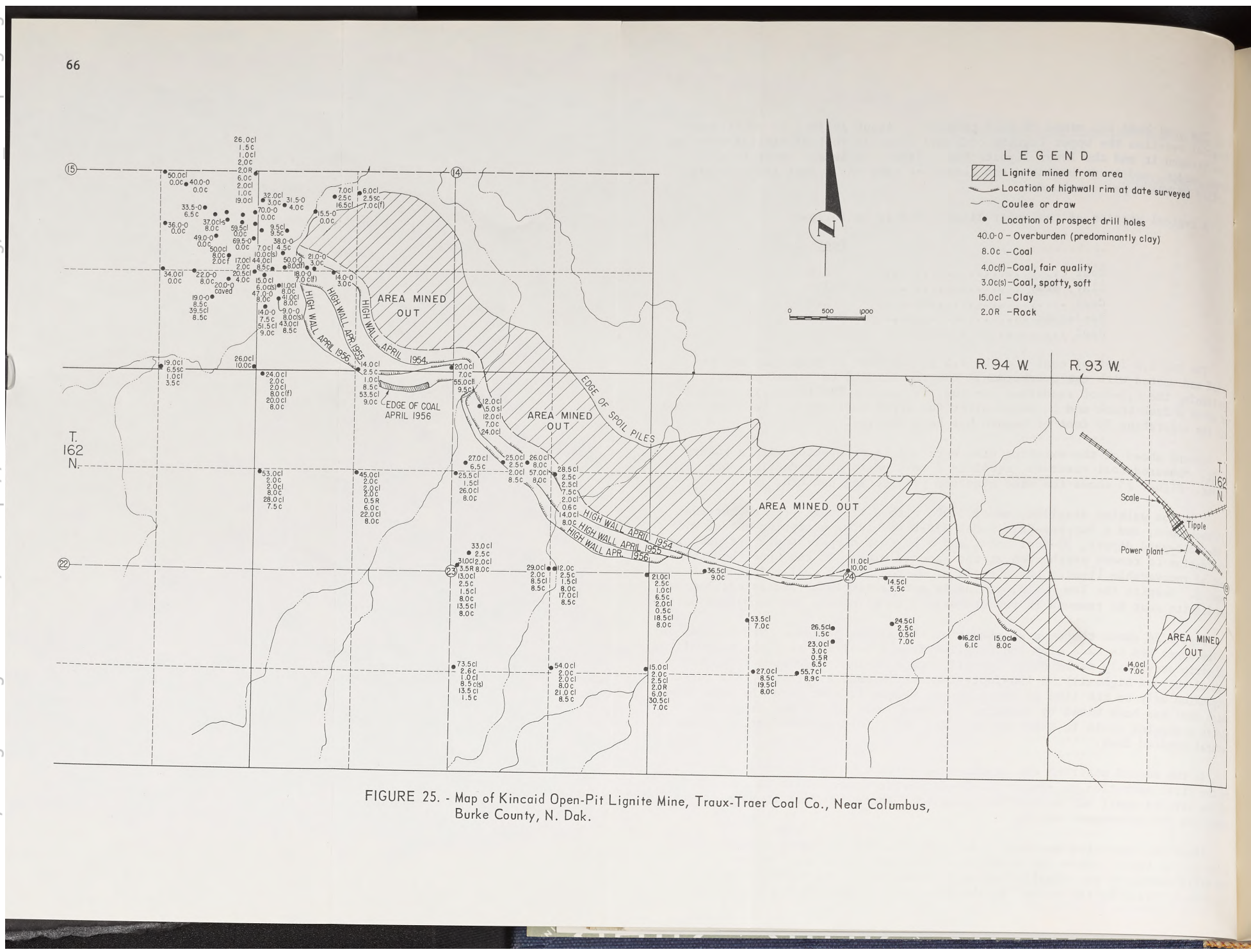

FIGURE 25. - Map of Kincaid Open-Pit Lignite Mine, Traux-Traer Coal Co., Near Columbus, Burke County, N. Dak.

Generated on 2024-09-21 17:44 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

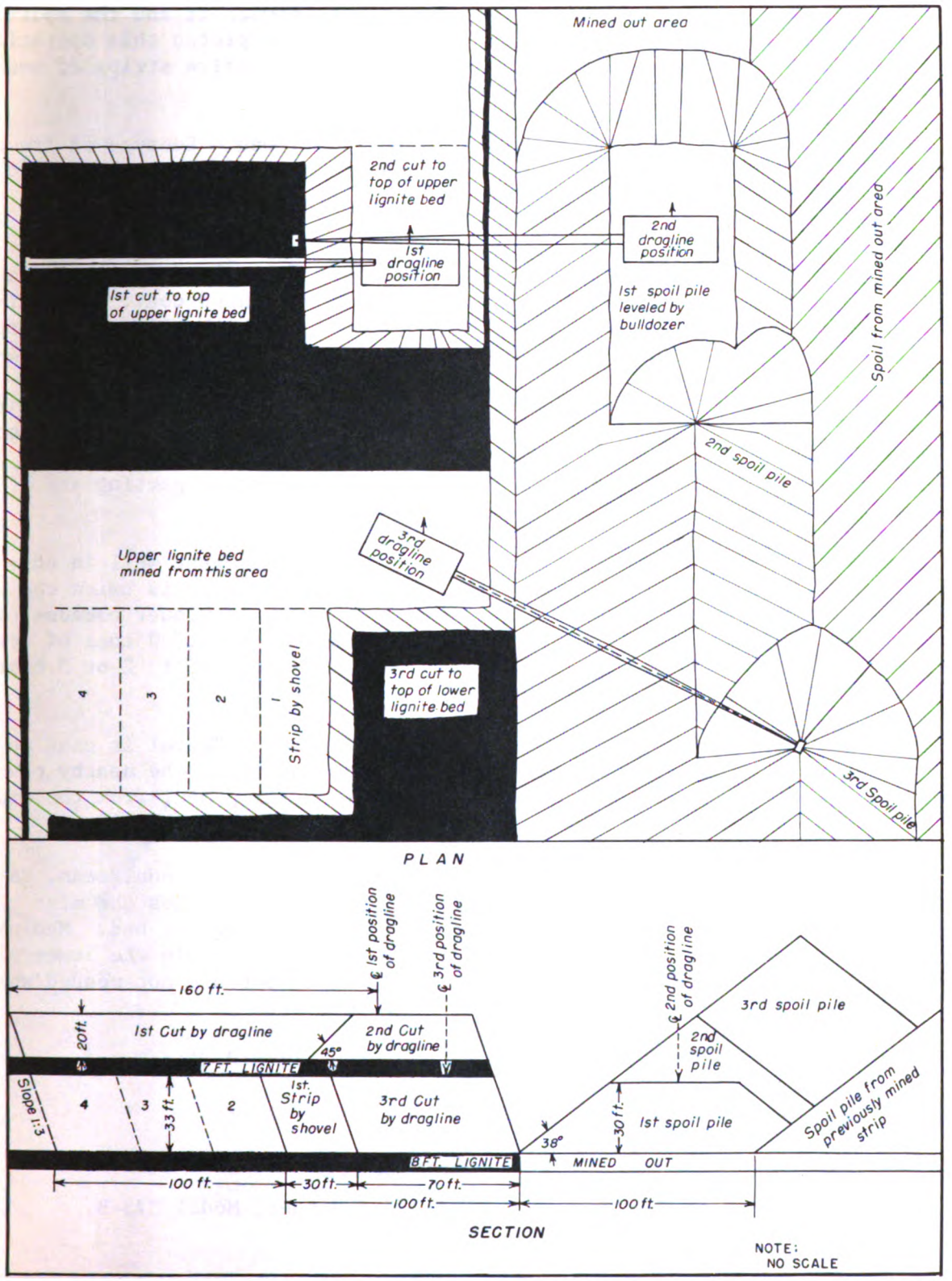

FIGURE 26. - Plan for Removing Overburden From Two Lignite Coal Beds With a Marion-Model 7400 Walking Dragline at Kincaid Mine, Truax-Traer Coal Co., Columbus, N.Dak.

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

is cast over the second spoil pile into the trough between it and the spoil from the strip previously mined. After the dragline completes this operation, the lignite in the exposed lower bed is mined, and successive strips of overburden 30 to 40 feet wide are removed with the shovel.

No blasting is required in mining the upper coal bed. Because of freezing the lower bed must be blasted from October through March. The drilling and blasting practices are similar to those at other mines in the area.

The recoverable lignite of the upper bed is mined and loaded with two electric-powered shovels operating in series. (See fig. 27.) Four to five strips are made to mine the 200-foot-wide bench of uncovered coal. The first strip is advanced with one of the shovels along the new highwall, recovering the lignite down to the sandstone parting. Successive strips work progressively toward the spoil-pile side of the pit. When the first shovel has advanced enough to permit equipment to operate behind it, the sandstone parting is removed by a bulldozer or Payloader and stored in piles along the edge of the advancing pit. The second shovel now begins mining the remaining 4 to 5 feet of lignite. As the shovel advances, piles of sandstone parting are bulldozed into the pit behind it.

The shovel used to load the upper part of the bed is kept well in advance of the shovel mining the lower part. Although the lower part is twice the thickness of the upper part, advance in the upper bench is slower because of partly filled dippers and extra traveling required. About 1,700 tons of coal can be mined from the upper part of the bed per 7.25-hour shift; 2 or 3 times that much can be mined from the lower bed in the same time.

Ramps to the pit are built through the spoil piles. Gravel is used to surface the main haulage roads. Coal clinker and ashes from the nearby powerplant are used to surface secondary roads. The round-trip haul from the mine pit to the tipple is about 5 miles.

Water is not present in appreciable amounts in the upper coal seam. A 2.5-inch discharge pump, working intermittently, readily empties the mine sump. A moderate amount of water is found in the lower lignite bed. Medium-size pumps, working independently or in parallel, readily drain the lower pit. Coal-berm roads are used in the lower part of the pit but are not needed when the top bed is being mined.

The following mining equipment is used at the Kincaid mine:

Stripping Equipment

Quantity	Description
1	Stripping shovel, 10-cubic-yard dipper, Model 375-B, Bucyrus-Erie Co.
1	Stripping and walking dragline, 12-cubic-yard bucket, Model 7400, Marion Power Shovel Co.

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

FIGURE 27. - First Phase of Stripping With Dragline, and Mining Split Upper Lignite Bed With Two Shovels Working in Series, Kincaid Mine, Truax-Traer Coal Co.

Original from THE OHIO STATE UNIVERSITY

Loading Equipment

Quantity	Description
2	Power shovels, 3-1/2-cubic-yard dippers, Model 50-B, Bucyrus-Erie Co.

Auxiliary Equipment

2	Bulldozers, Model D-8, Caterpillar Tractor Co.
1	Bulldozer, gasoline motor, Model 50, Caterpillar Tractor Co.
1	Patrol, Model 11, Caterpillar Tractor Co.
1	Front-end loader, Payloader, F. G. Hough Co.
1	Front-end loader, Model Industrial 88, Oliver Corp.
1	Wagon drill, Chevrolet transmission, 5-hp. motor, made in mine shop.

Transportation Equipment

8	Trucks, 20-ton-capacity, bottom-dump, Model 27-FTD-83W, Euclid Div. General Motors Corp.
2	Railroad locomotives, 121-ton, 2400 class.

Pumping Equipment

2	Pumps, centrifugal, 3-inch-discharge, 10- and 15-hp., electric motor, Gorman-Rupp Co.
1	Pump, centrifugal, 2-inch-discharge, 7-1/2-hp., electric motor, Gorman-Rupp Co.
2	Pumps, centrifugal, 1-1/2-inch-discharge, 5-hp., gasoline motor, Wisconsin, Gorman-Rupp Co.
2	Pumps, centrifugal, 2-1/2-inch-discharge, 10-hp., electric motor, Baldor Electric Co.

Figure 28 shows a schematic flow plan of the preparation plant at the Kincaid mine. A powerplant operated by Montana-Dakota Utility Co. is adjacent to the tipple. The powerplant is supplied with fuel by a conveyor belt extending directly to its stockpile. Table 7 gives the installed equipment and rated horsepower of individual driving motors in the tipple.

Generated on 2024-09-21 17:46 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

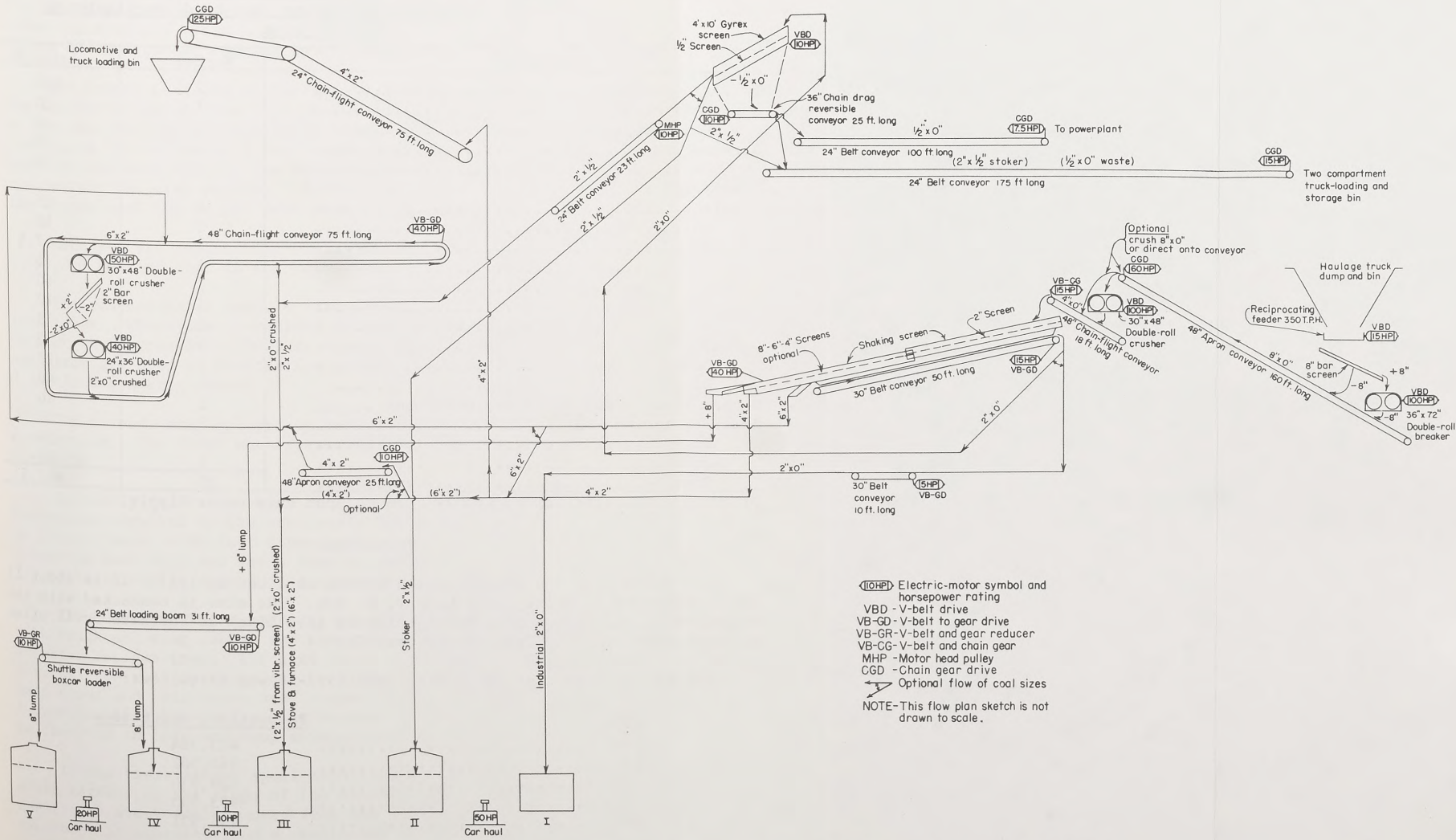

FIGURE 28. - Flow Plan of Kincaid Mine Preparation Plant, Truax-Traer Coal Co., Near Columbus, Burke County, N. Dak.

Generated on 2024-09-21 17:36 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 7. - Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Kincaid mine

Equipment	Number	Rated hp.
Primary crushers	2	100
Secondary crushers	1	50
Do.	1	40
Screens	1	40
Do.	1	10
Conveyors:		
Belt	2	15
Do.	3	10
Do.	1	7.5
Do.	1	5
Apron or pan	1	60
Do.	1	10
Do.	1	15
Chain-flight	1	15
Do.	1	25
Do.	1	40
Boxcar loaders and auxiliary equipment	1	10
Railroad car hauls 1/	1	50
Do.	1	20
Do.	1	10
Total	23	667.5

1/ Hoists (locally called crabs) used to spot cars under tipple.

Velva Mine

The Velva mine was opened in the Coteau coal bed in 1927. It is about 13 miles southwest of Velva, Ward County, N. Dak. The mine is connected with the Minneapolis, St. Paul & Ste. Marie Railroad (Soo Line) at Voltaire by 11 miles of spur track owned by Truax-Traer Coal Co.

Annual production of Velva mine from 1952-56 was as follows:

Year	Production, short tons
1952	433,764
1953	465,582
1954	420,830
1955	473,495
1956	496,931

Forty-five men are employed at the mine, including the railroad crew, watchman, office, and supervisory force. Their classifications and wage scales are similar to those of the Kincaid mine.

The daily production ranges from 2,400 to 3,100 tons of coal, and averages about 2,800 tons. At maximum operating capacity, 3,500 tons a day could be produced.

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

The overburden ranges from 30 to 75 feet in thickness. A blue-gray clay 15 to 20 feet thick, containing sand and pebbles, overlies the coal. Above the clay the stratum is argillaceous material containing concretions and lenses of sandstones, ranging in color from drab yellow to buff.

The Coteau coal bed at Velva dips gently southward and undulates locally. Its thickness ranges from 6 to 18 feet and averages 14 feet. On the west side of the mine the bed is relatively consistent in thickness but contains a clay parting, a few inches to 3 feet thick, about 4 feet above the bottom of the bed. On the east side of the mine the bed is irregular in thickness but does not contain the clay parting. Silicified logs are found in the upper part of the Coteau coal bed in the west part of the mine.

Rotary-drill prospecting has developed a measured reserve of about 2,000,000 tons of coal in the Velva ground.

The overburden is removed with a power shovel where it is less than 40 feet thick. Where the overburden is over 40 feet thick and is not more than 70 feet, a Bucyrus-Erie 750-B stripping shovel and a Bucyrus-Erie TX-310 tower excavator are used in combination. Overburden-to-lignite ratios range between 2 and 10 but average about 5.

Two methods are employed to remove the overburden, using the 2 machines in combination. The first method is diagrammed in figure 29 and pictured in figure 30.

Initially, a 40-foot-wide cut is made with the shovel through the overburden and parallel to the previously mined-out strip. The shovel used has an 85-foot boom, a 60-foot dipper arm, and a 22-cubic-yard dipper. It can cut a face 82 feet high and has a dumping radius of 99 feet. The spoil from the first shovel cut is dumped into the mined-out area.

The tower excavator consists of two self-propelled, tractor-mounted towers with track and drag cables and ropes so arranged that a bucket scraper can move material between them. The head tower is placed on the leveled spoil pile, and the tail tower is operated on the highwall. The track-cable sheaves on the head tower and tail tower are, respectively, 130 and 30 feet above the ground. A Sauerman 12-cubic-yard bucket scraper is pulled between the towers and can be operated to load and dump anywhere within the span.

In the first method spoil deposited by the shovel in the first cut is moved farther up the slope of the existing spoil pile to provide space for the additional overburden removed from the second shovel cut. Because the tower excavator is operated from a stationary position, the action of the scraper is confined to a plane normal to the direction of the strip pit. The operation is usually started near the base of the first spoil pile, even with the top of the coal, and the material is dragged toward the high tower. The towers remain in their respective positions until the bottom of the trench formed by the scraper is level with the top of the coal. After all the readily handled material has been moved, the tail and head towers are moved simultaneously a short distance ahead in the direction of the pit advance. This procedure is followed until all the spoil from the first cut above the level of the coal is

Generated on 2024-09-21 17:42 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

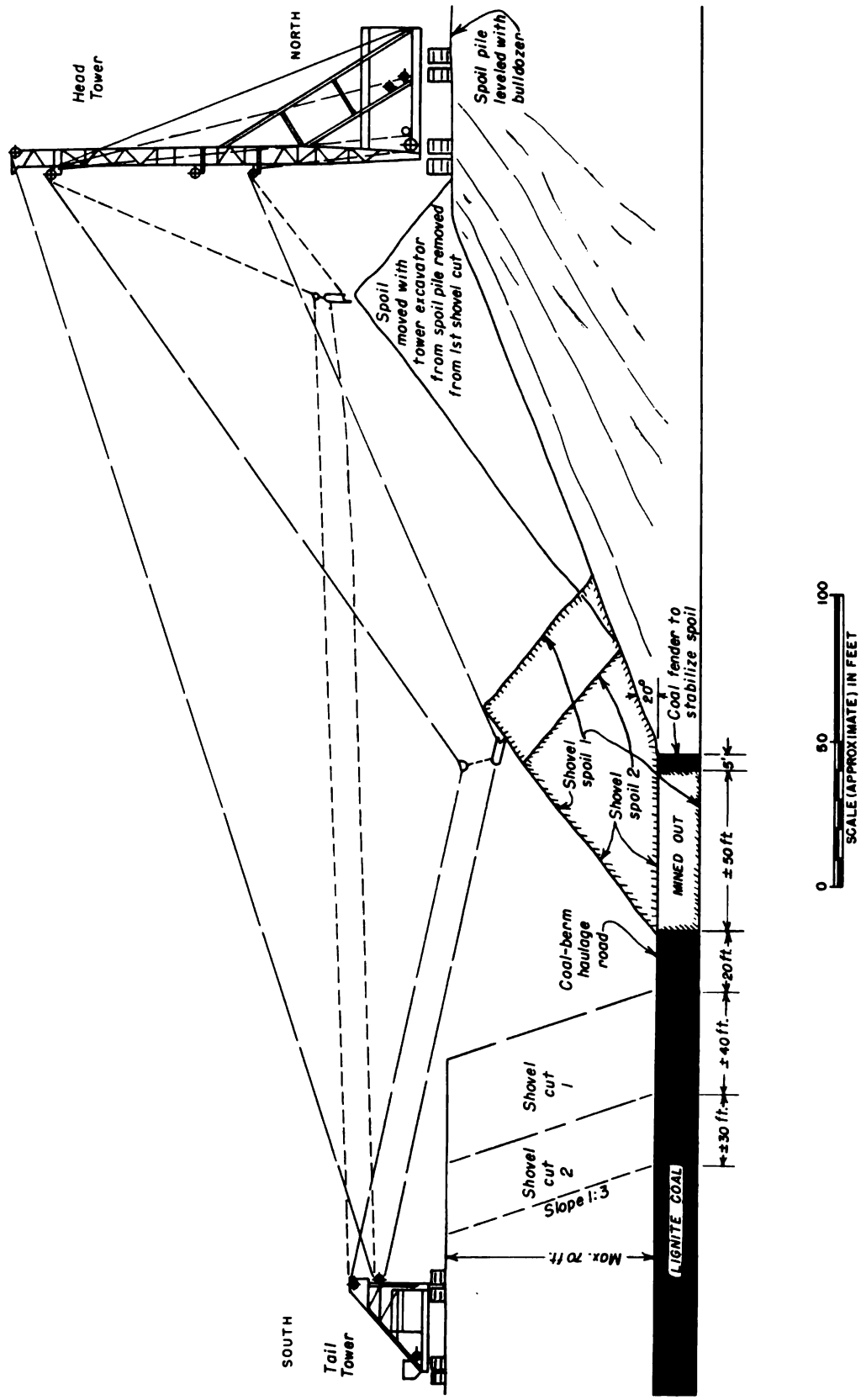

FIGURE 29. - Stripping Overburden by Using a Shovel and Tower Excavator in Tandem at Velva Mine, Truax-Traer Coal Co., Velva, Ward County, N. Dak.

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:41 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

FIGURE 30. - Revolving Shovel and High-Tower Excavator Operating in Series to Remove Overburden at Velva Mine, Truax-Traer Coal Co.

Digitized by Google
Original from THE OHIO STATE UNIVERSITY

moved and space has been provided for the material spoiled from the second cut, which will be about 30 feet wide. The combined width of cuts 1 and 2 is 70 feet.

In the second method the upper 20 feet or more of overburden is removed with the tower excavator, forming a cut 150 feet wide. The spoil from this cut is placed as close as possible to the head tower. (See fig. 31.) Digging is continued until about 40 feet of overburden remains above the coal. The stripping shovel is then used to remove the remaining overburden, usually in 3 strips, each 50 feet wide. The coal is mined as each successive strip is cleared.

During winter the overburden and coal become frozen, and drilling and blasting are necessary for efficient stripping and loading. Usually, the upper 3 or 4 feet of the ground to be stripped is frozen. Blast holes, drilled in a square pattern to the frostline, are loaded with 3 or 4 sticks of explosive, stemmed with clay, and detonated with electric blasting caps set off by a permissible 10-cap-capacity magneto blasting machine. The same procedure is used to break the coal except that the distance between the holes generally equals the thickness of the coal bed. However, the holes are never more than 12 feet apart, even where the coal bed is thicker.

In the first method of stripping the uncovered lignite bed is about 70 feet wide. The mining is advanced on a 50-foot-wide face with a road berm of 20 feet for a haulageway.

The electric-powered loading shovel with a 6.5-cubic-yard bucket travels on the clay floor under the mined-out coal. The mined area is separated from the spoil pile by a thin fender of coal to prevent the spoil from slumping into the pit. Four dipperloads usually fill the 20-ton-capacity trucks. The coal strip is mined the full length of the stripped coal. In some places mining can proceed in the same direction for the entire length of the pit or between the access and egress ramps. In other places, where the slope of the coal bed changes locally, the direction of mining is changed so the water will drain from the working face. Bulldozers and Payloaders are used in conjunction with the loading shovel to clean up the loose coal in the mining area.

Water creates a major problem at this mine. Before the coal can be mined, large sumps and pumping stations must predrain and lower the water table below the working level in the east section of the pit. Predraining is not necessary in the western part of the pit, but continuous pumping is required to keep the water from the working area.

Pit-access ramps are built through the spoil pile and along the pit bottom are coal-berm roads. All haulage roads are surfaced with gravel. Gravel deposits are large enough to supply all anticipated demands but occur about 1 mile from the nearest point of use.

Maximum distance between the mine pit and preparation plant is 3 miles.

Major mining equipment of Velva mine is as follows:

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

Generated on 2024-09-21 17:40 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google

Digitized by Google

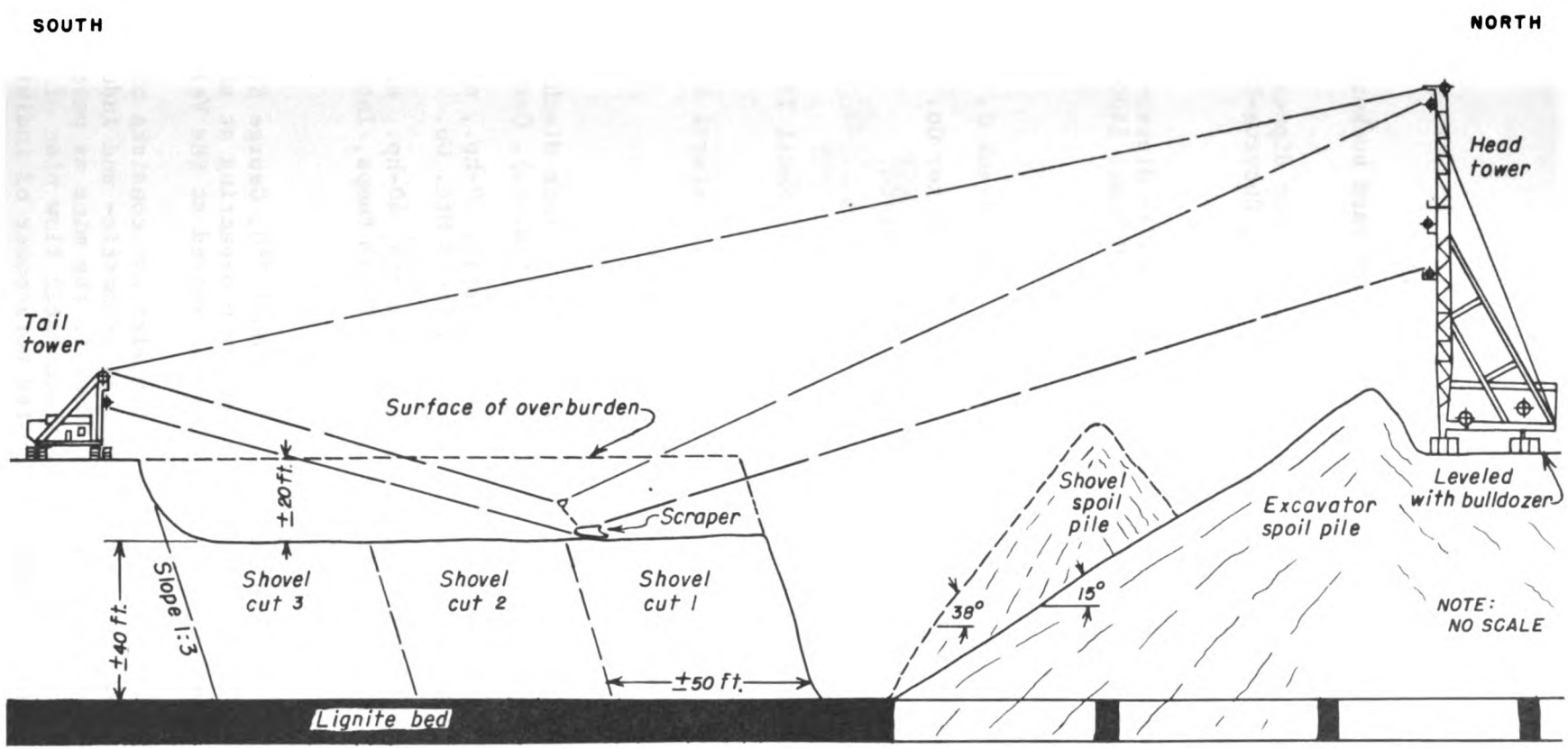

FIGURE 31. - Alternate Method Used to Remove Overburden at Truax-Traer Coal Co., Velva Mine, Using a Tower Excavator and a Stripping Shovel.

Original from THE OHIO STATE UNIVERSITY

Stripping Equipment

Quantity	Description
1	Tower excavator, Sauerman 12-cubic-yard bucket-scraper, Model TX-310, Bucyrus-Erie Co.
1	Stripping shovel, 85-foot boom, 60-foot dipper arm, 22-cubic-yard dipper, Model 750-B, Bucyrus-Erie Co.

Loading Equipment

1	Shovel, 36-foot boom, 25-foot straddle dipper-sticks, 6-1/2-cubic-yard coal-dipper, P-H Model 1400, Harneschfeger Corp.

Auxiliary Equipment

1	Front-end scoop loader, Model 90568, Frank G. Hough Co.
1	Bulldozer, Model D-8, Caterpillar Tractor Co.
1	Patrol, Model 12, Caterpillar Tractor Co.

Transportation Equipment

6	Trucks, 20-ton-capacity, bottom-dump, Model 27-FTD-83-W, Euclid Div. General Motors Corp.
1	Railroad locomotive, 65-ton, diesel, General Electric Co.
1	Railroad locomotive, 130-ton, steam.

Pumping Equipment

5	Pumps, self-priming, centrifugal, 3-inch discharge, 25-hp., electric motor (200 volt, a.-c.), Gorman Rupp Co.
1	Pump, centrifugal, 4-inch discharge, 30-hp., electric motor (220-volt, a.-c.), Allis Chalmers Mfg. Co.
1	Pump, centrifugal, 6-inch discharge, 40-hp., electric motor (220-volt, a.-c.), American-Marsh Pumps, Inc.

Prospecting Equipment

1	Failing Hole Master drill, Model 750, George E. Failing Co. This drill is used for prospecting at all Truax-Traer Company mines but was stored at the Velva mine.

The new preparation plant at the Velva mine now consists of an integrated series of crushers and screens to produce all domestic- and industrial-size fuel. Built in 1954, it was placed as close to the mine as possible to reduce the haulage distance. Figure 32 shows a schematic flow plan of the tipple. Table 8 lists the major equipment and rated horsepower of individual driving motors.

Generated on 2024-09-21 17:45 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

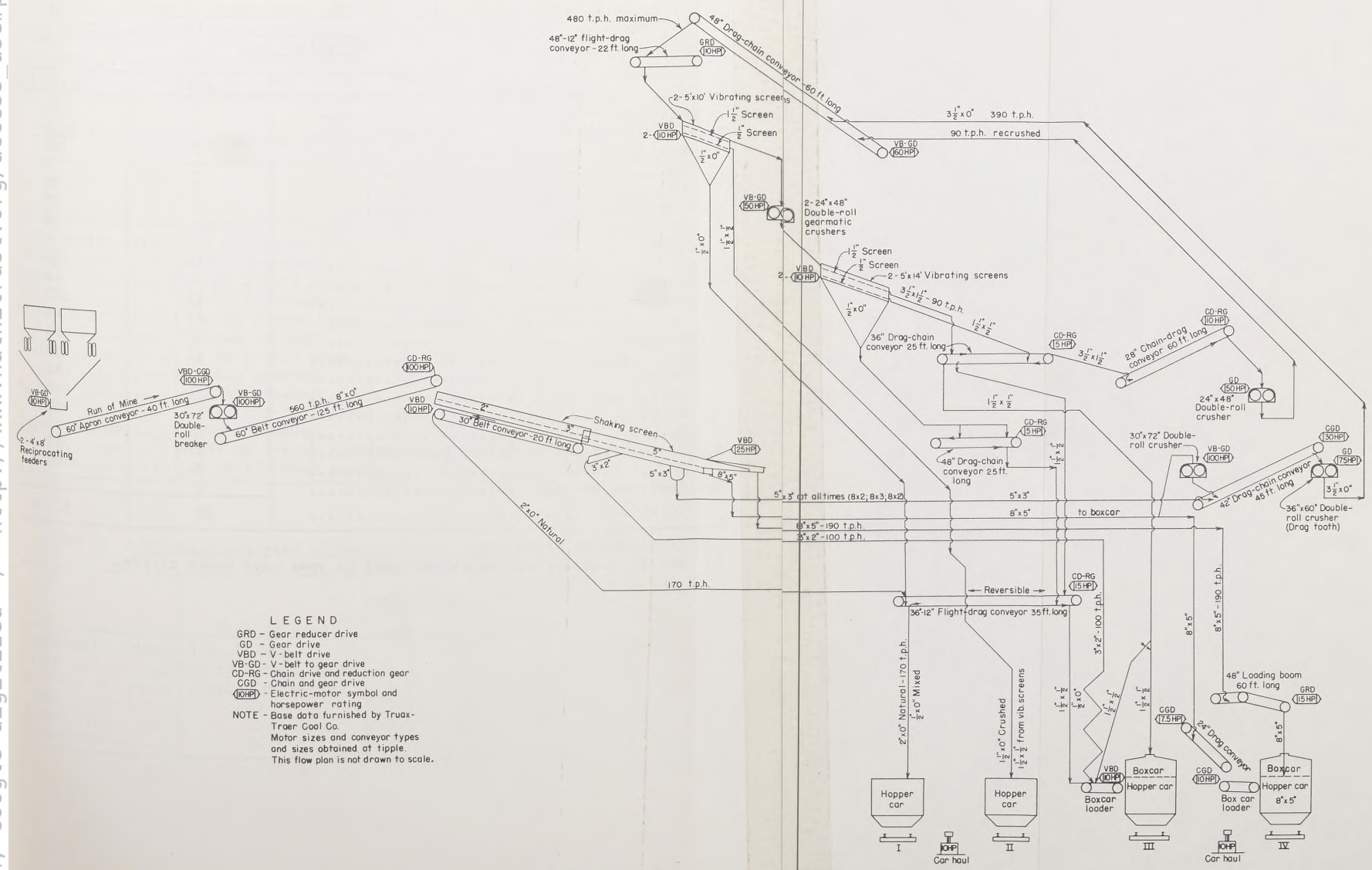

FIGURE 32. - Flow Plan of Velva Mine Preparation Plant, Truax-Traer Coal Co., Ward County, N. Dak.

Generated on 2024-09-21 17:37 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 8. - Equipment units and rated horsepower of motors used in crushing, screening, conveying, and handling lignite at Velva mine

Equipment	Number	Rated hp.
Primary crushers	1	100
Secondary crushers	2	1/ 50
Do	1	100
Do	1	75
Do	1	50
Screens	1	25
Do	4	10
Conveyors:		
Belt	1	100
Do	1	10
Apron or pan	1	100
Do	1	10
Chain-flight	1	15
Do	1	30
Do	2	10
Do	2	5
Do	1	60
Do	1	7.5
Boxcar loaders and auxiliary equipment	1	15
Do	2	10
Railroad car hauls 2/	2	10
Total	28	857.5

1/ Single motor drive.
2/ Hoists (locally called crabs) used to spot card under tipple.

Generated on 2024-09-21 17:49 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

APPENDIX

The following tables were prepared from data furnished by the Branch of Coal Technology, Federal Bureau of Mines, Region III, Denver, Colo. The analyses of the selected samples of North Dakota lignite were made by the Analysis Section, Central Experiment Station, Bureau of Mines, Region V, Pittsburgh, Pa.

TABLE 9. - Proximate analyses of North Dakota lignite on as-received basis

Mine	Size of coal	Proximate analyses, weight-percent			
		Moisture	Volatile matter	Fixed carbon	Ash
Beulah-Knife River	10- by 4-inch lump	37.1	26.3	31.2	5.4
Do.	2-inch crushed	37.4	25.9	30.4	6.3
Velva	8- by 5-inch lump	40.7	26.1	28.5	4.7
Do.	2- by 1/2-inch crushed	39.7	26.1	28.1	6.1
Dakota Star	18- by 8-inch lump	37.3	26.0	30.6	6.1
Do.	2-inch crushed	37.2	26.7	30.4	5.7
Custer	8- by 6-inch lump	40.2	26.7	29.0	4.1
Do.	2-inch crushed	39.6	27.1	28.2	5.1
Kincaid	2-inch crushed	34.1	24.9	34.8	6.2
Do.	1/2- by 0-inch slack	34.5	24.0	31.5	10.0
Baukol-Noonan	2-inch crushed	34.6	26.6	32.8	6.0
Do.	1/4- by 0-inch slack	34.6	24.8	29.8	10.8
Do.	2- by 1/2-inch screen	33.1	27.2	31.4	8.3

TABLE 10. - Ultimate analyses of North Dakota lignite on as-received basis

Mine	Size of coal	Ultimate analyses, weight - percent					
		Hydrogen	Carbon	Nitrogen	Sulfur	Oxygen	Ash
Beulah-Knife River	3-inch lump	7.0	41.7	0.5	0.9	44.2	4.7
Velva	8- by 4-inch stove	7.1	40.2	.5	.2	48.1	3.9
Dakota Star	Crushed mine-run	6.9	41.6	.6	.8	44.6	5.5
Custer	do	7.1	40.0	.7	.3	47.4	4.5
Kincaid	do	6.7	42.6	.7	.4	43.3	6.3
Baukol-Noonan	do	6.7	42.0	.8	.5	42.9	7.1

Generated on 2024-09-21 17:38 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY

TABLE 11. - Heat value of North Dakota lignite, British thermal units

Mine	Size of coal	As-received	Moisture-free	Moisture- and ash-free
Beulah-Knife River	10- by 4-inch lump	6,920	10,990	12,010
Do.	2-inch crushed	6,730	10,770	11,970
Velva	8- by 5-inch lump	6,550	11,050	11,990
Do.	2- by 1/2-inch crushed	6,440	10,690	11,900
Dakota Star	18- by 8-inch lump	7,010	11,170	12,380
Do.	2-inch crushed	6,980	11,100	12,200
Custer	8- by 6-inch lump	6,630	11,080	11,890
Do.	2-inch crushed	6,630	10,960	11,970
Kincaid	2-inch crushed	7,630	11,570	12,760
Do.	1/2- by 0-inch slack	7,060	10,780	12,710
Baukol-Noonan	2-inch crushed	7,360	11,260	12,390
Do.	2- by 1/2-inch screened	7,400	11,060	12,630
Do.	1/4- by 0-inch slack	6,850	10,480	12,550

TABLE 12. - Fusibility of North Dakota lignite ash, °F.

Mine	Size of coal	Initial deformation temperature	Softening temperature	Fluid temperature
Beulah-Knife River	10- by 4-inch lump	2,440	2,510	2,570
Do.	2-inch crushed	2,310	2,500	2,560
Velva	8- by 5-inch lump	2,420	2,520	2,570
Do.	2- by 1/2-inch crushed	2,360	2,380	2,420
Dakota Star	18- by 8-inch lump	2,070	2,380	2,460
Do.	2-inch crushed	2,320	2,420	2,470
Custer	8- by 6-inch lump	2,520	2,590	2,590
Do.	2-inch crushed	2,510	2,540	2,570
Kincaid	2-inch crushed	2,080	2,180	2,280
Do.	1/2- by 0-inch slack	1,990	2,070	2,190
Baukol-Noonan	2-inch crushed	2,060	2,150	2,360
Do.	2- by 1/2-inch screened	2,030	2,130	2,210
Do.	1/4- by 0-inch slack	1,990	2,040	2,140

INT.-BU.OF MINES, PGH., PA. 9913

Generated on 2024-09-21 17:39 GMT / https://hdl.handle.net/2027/osu.32435030643415
Public Domain, Google-digitized / http://www.hathitrust.org/access_use#pd-google
Digitized by Google
Original from THE OHIO STATE UNIVERSITY